

The Blast Furnace and Steel Plant

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The Blast Furnace *and* Steel Plant

Vol. XIV

PITTSBURGH, PA., MARCH, 1926

No. 3

Pittsburgh—Forward

PERIODICALLY something comes up to disturb the self-complacency of Pittsburghers. Last year it was the urge to build an outstanding educational institution; this year it seems to be necessary to record a civic inventory.

Pittsburgh, the Steel City, is not satisfied with itself. Steel, the industry, which has always been classed as Prince or Pauper, seems to have inflicted the "prince or pauper" characteristic upon its mother community. The analytical doctors of business are now busy cataloging the symptoms and in due season will offer prescriptions for her permanent cure. But the value of the nostrums will depend upon the accuracy of the diagnosis.

Meanwhile, and irrespective, the great steel organizations, which are the very foundation and structure of Pittsburgh, will go ahead with carefully developed plans for expansion and internal improvement. Clairton will build additional by-product ovens, which will replenish the waning natural gas supply. Homestead, Woodlawn, and similar great groups of rolling mills will completely electrify; and all of these companies will continue their program of river transportation which will coincide with the final plans of the Inland Waterways engineers.

The Pittsburgh Forward movement, like all movements of similar nature, has its logical place in the scheme of things. If it results in nothing more than an inventory disclosure that Pittsburghers live in an atmosphere of increasing opportunity, that Pittsburgh possesses resources and organizations unrivaled anywhere else, that Pittsburgh as a community is universally recognized as a distinct personality which is not at all dependent upon mere numerical population, and if the movement succeeds in getting these truths "over," it will have justified itself.

Concerning Elimination and Recovery of Phenols from Crude Ammonia Liquors

By ROBERT M. CRAWFORD*

WASTE liquors from coke plant ammonia stills constitute a known source of stream pollution due to the presence of very appreciable quantities of Phenol and Cresols, which are scrubbed out of the gas by the flushing liquors and which ultimately reach a stream via ammonia still wastes. In the crude ammonia liquor the phenols exist in solution in the "free" state, but when lime is added in the still to decompose the "fixed" ammonia, most, if not all, of the phenols are "fixed" and pass into the still waste as calcium phenolates. This "fixing" of the phenols probably accounts for the fact that the phenols are not often found in the "free" state in the still wastes. However, due to the absorption of carbon dioxide from the atmosphere adjacent the waters of a stream, or due to mineral acids in the stream perhaps, the phenolates are decomposed thus liberating the phenols in "free" state. The free phenols thus constitute a source of stream pollution. This liberation may take place a considerable distance down-stream from the offending coke-plant. It is not the purpose of this article to go into the mechanism of stream pollution by these phenols and the reader is referred to numerous writings in the chemical literature which deal with this particular phase of the subject.

In order to prevent such stream pollution, it has become customary practice in the coke oven industry to quench the hot coke with ammonia still wastes, which affords a simple and easy means of disposal. This method, however, seems to have certain obvious objections; first, the phenols are completely vaporized with the water and are dissipated into the atmosphere only to condense and collect on surrounding territory; perhaps to be washed into a stream by natural rainfall; second, corrosive compounds contained in the still waste, or formed during quenching of hot coke, give rise to rapid deterioration of quenching equipment; third, a marked discoloration and a disagreeable odor is imparted to the coke which effects its sale for domestic purposes; and fourth, if suspended calcium salts exist in the still wastes, clogging of the coke pores results which prevents the free burning of furnace coke.

In the investigation of commercial means for the possible recovery of the phenols from the crude liquor, the writer recalled a method used early in the World War, for recovering phenol from the waste liquors from synthetic phenol fusions. This method consisted simply in extracting the waste liquors with Benzol, which dissolved out the phenol. Dawson, in the Journal of The Society of Chemical Industry, June, 1920, describes a similar method used in England for the same purpose. For the recovery of the phenol from the Benzol extract, the method suggested by Weiss in 1916 offered the most likely procedure, which was to remove the phenol from the Benzol extract by means of a solution of caustic soda. These basic methods of procedure were found to offer practical

possibilities which have been demonstrated successfully on a commercial scale by an installation designed and installed by the Foundation Oven Corporation, New York, for the Hudson Valley Coke & Products Corporation, Troy, N. Y., the writer acting as Consulting Engineer. A similar process has also been demonstrated commercially by the National Tube Company, to whom credit is due for pioneering the method commercially, and also the Iroquois Gas Corporation; these three installations operate over the same basic principles, as described, and differ only in details of operation.

For the purpose of describing the system clearly reference is made to the flow sheet:

The crude ammonia liquor is pumped continuously into a distributor line located somewhat below the top of No. 1 extractor, the liquor in the extractor being maintained at the distributor pipe level by means of an inverted U pipe overflow line. The liquor flows downwards in the extractor, leaves via the overflow line, and is collected in a surge tank comprising the lower portion of the No. 2 extractor. From the surge tank the liquor is then pumped to the distributor line near the top of No. 2 extractor and leaves via No. 2 overflow line flowing by gravity to storage, for the dephenolated liquor. Ninety per cent Benzol (or Motor Fuel) is passed in the opposite direction in each extractor by being pumped into spray distributor pipes submerged in the ammonia liquor near the bottom of each ammonia liquor extractor. The finely divided Benzol Spray enters first at the Bottom of No. 2 extractor, floats upwards through the down-flowing ammonia liquor exposing an enormous surface for extraction. Upon reaching the liquor level near the top, the Benzol extract separates out as a supernatant layer which overflows into the spray distributor line at the lower part of No. 1 extractor in which it performs the same function. By means of this continuous counter-current extraction system, it is obvious that the desirable conditions for maximum extraction efficiency are fulfilled. Actual tests show an extraction efficiency of 98 to 99 per cent.

The strong Benzol extract leaving No. 1 liquor extractor overflows to the spray line in No. 3 extractor where it is sprayed into a solution of caustic soda, while the overflow from No. 3 extractor goes to the spray line in No. 1 extractor, also charged with caustic soda solution, and the overflow from No. 4 extractor, runs to the benzol circulating tank for re-use. The benzol thus is seen to cycle as a transfer medium taking the phenol from the ammonia liquor and delivering it to the caustic soda.

The caustic solution in the caustic extractors, gradually reverts to sodium phenolate, by the absorption of phenol and on account of the strength of caustic necessary for the proper absorption it is not practical to run the caustic extractors continuously, as is the case with the liquor extractors; instead, when the solution in No. 3 is saturated with phenol it is withdrawn, replaced with the partially saturated solu-

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tion from No. 4 and fresh caustic put into No. 4. During the caustic change-over each caustic extractor is by-passed to prevent interrupting the liquor-benzol cycle. The saturated caustic soda (sodium phenolate) withdrawn for No. 3 extractor contains, in addition to phenol, cresols and small quantities of high tar acids; some benzol and also impurities such as pyridine bases, naphthalene, etc., which must be removed to prevent contamination of the final crude phenol if the latter is to be purified. The removal of these offending impurities is affected by simple steam distillation. The dissolved benzol is recovered during the early part of the steam distillation by condensing the vapors and decanting the distillate.

acid, and are either discarded or worked up for the recovery of crude pyridine bases for sale.

The liberation of the free phenols from the steamed phenolate solution can be done by neutralizing with sulphuric acid or by carbon dioxide gas from some convenient source. Neutralization with sulphuric acid is done by adding the acid to a batch of phenolate in an agitated tank equipped with cooling coils and decanting off the liberated phenols after settling. The lower layer of sodium sulphate solution generated by neutralizing with sulphuric acid contains considerable phenol in solution which can be recovered by adding the waste sulphate solution to the crude ammonia liquor entering the liquor extractor system. Scaling

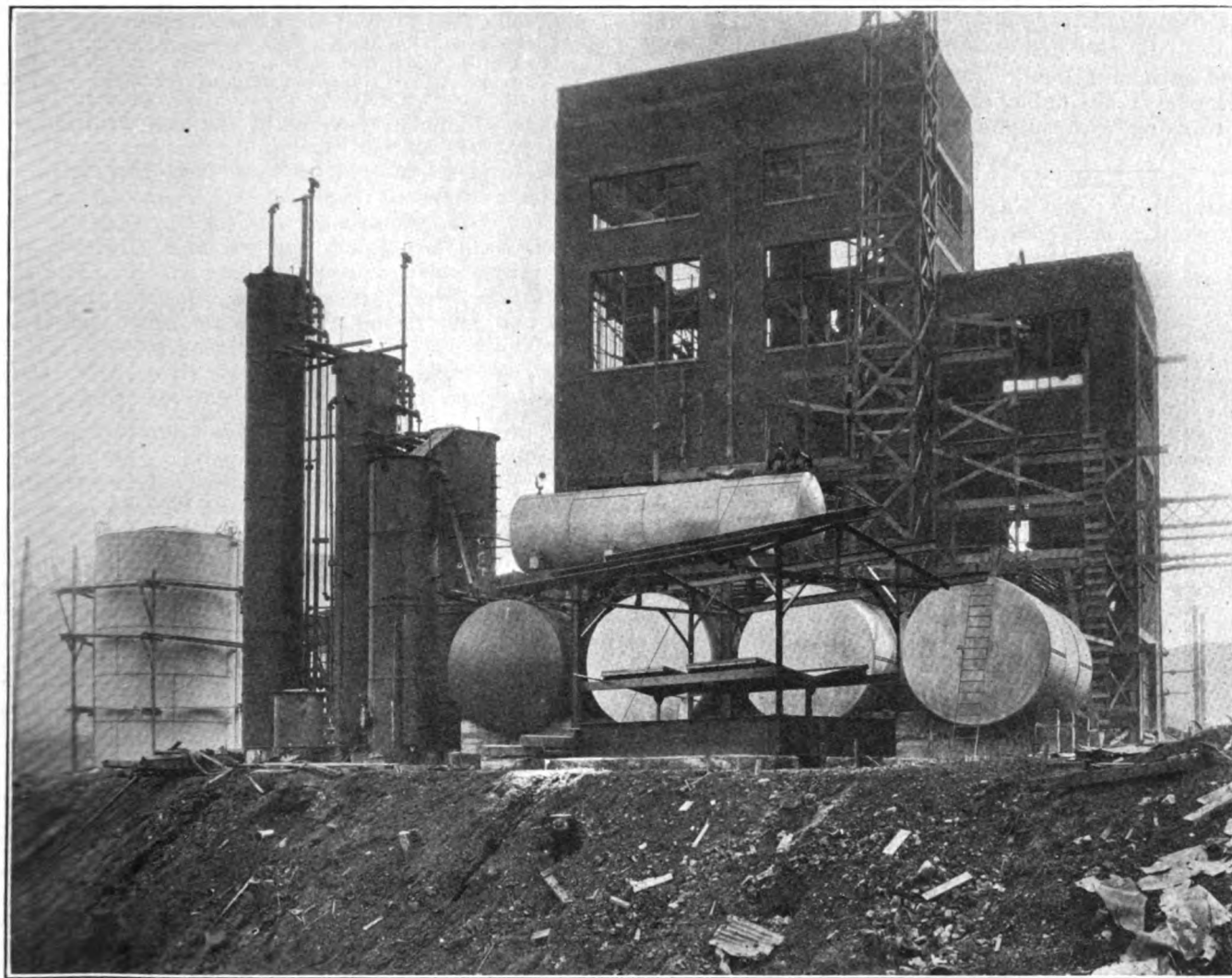


FIG. 1—An excellent view showing phenol recovery installation recently made at the plant of the Hudson Valley Coke & Products Corporation, Troy, N. Y., where a new blast furnace was recently blown in.

Since the pyridine bases dissolved from the ammonia liquor by the benzol are not soluble in the caustic soda it is obvious that unless provision is made to prevent the accumulation of these bases, the cycling benzol will become fouled. In order, then, to keep the pyridine bases to a low concentration, a portion of the cycling benzol is bled continuously from the system and sent through a small extractor containing dilute sulphuric acid which removes the pyridine, forming the pyridine sulphates. The pyridine sulphates collected in solution in this operation are removed from time to time, being replaced with fresh

of ammonia stills due to any calcium sulphate formed from the waste sulphate liquor and the still lime has been found to be negligible.

Neutralization by means of carbon dioxide gas is conducted by bringing about an efficient absorption of the gas by the alkali phenolate. In this process the crude phenols separate out as with the sulphuric method, but the lower layer of spent liquor in this case consists of a solution of sodium carbonate. At the Troy installation the carbon dioxide method is found practical because the sodium carbonate solution generated in neutralization can be used as makeup for

New Electric Blooming Mill Drive Installed in Record Time

By A. L. FOELL*

THE installation of the new electric blooming mill drive recently put in operation by the Donner Steel Company, Inc., stands out as a unique accomplishment in the steel industry. The new drive replaces the 48x60-inch simple, twin cylinder MacIntosh-Hemphill engine formerly used in driving the 36-in. blooming mill at the Buffalo Works. This engine had been in service since 1906 and was operated non-condensing, by steam furnished in part from a battery of coal-fired boilers in one boiler house and from blast furnace gas fired boilers of another boiler house. Since the blooming mill in this plant is most essential in the production of alloy and special steels made to customers' specifications, it was important that the change be made with a minimum shutdown. After carefully planning every step and immediately upon receipt of the last car with electrical equipment from the factory, the mill was shut down on July 2, the old drive removed and again put in operation with the new drive in its place on July 20. The time from the last ingot with steam to the first ingot with electricity being just 18½ days.

The engine was typically located in one end of a lean-to building known as No. 1 Power House, which is adjacent to the blooming mill building proper and which also houses hydraulic pumps, boiler feed water pumps, accumulators, air compressors and numerous other power house equipments. This building being rather narrow and served by a rather low 10-ton electric overhead traveling crane, was found entirely inadequate for the purpose of housing the new drive. It, therefore, became necessary to erect a new building of ample size, with adequate crane facilities, to serve the needs of the reversing motor and auxiliaries, in place of a portion of the existing lean-to over the engine.

The construction of the new building carried with it certain difficulties not ordinarily encountered in work of this nature. Operation of the mill, before the final shut-down, could not be interrupted, in spite of the frequent occasions for interference with construction. The large steam separator, together with steam piping and exhaust piping serving the engine, as well as accumulators, hydraulic pumps and electrical apparatus in and near the engine room and used in conjunction with the mill, had to be moved in order to clear the site for foundations and walls of the new building.

The new building was designed approximately 7 ft. wider than the power house lean-to, so as to locate its east wall outside of the existing building. The foundation for this wall, on account of also having to carry the crane runway columns, had to be piled. Oak piles were first driven to refusal by a pile driver of special construction to drive these piles in the limited space between the existing power house building and a brick boiler house stack next to it. While the

excavation and concrete work for the east wall was in progress the end wall of the old power house building, together with roof and east wall in the last bay just south of the engine was removed to clear the site for the foundation and end wall of the new building, and for the switchboard basement which extends across the south end. Meanwhile, the brick wall separating the blooming mill building from No. 1 Power House was removed in five bays opposite the engine in order to expose the steel work of the mill building and to later permit the erection of a new partition wall, forming also the west wall of the new drive room.

After the east and south wall concrete foundations were in place, the erection of the steel work for the new building was started. Column extensions were added to the mill building columns for supporting the west ends of the drive building roof trusses about 5 ft. above the eave of the mill building. The east columns and roof trusses of the new building were then placed in their respective positions by the use of a hand-car on a track supported on the roof of the lean-to and raised by a portable gin pole, also supported from the same roof. Sufficient space was not available to erect the steel work from the ground by using ordinary erecting equipment for this purpose. The roof of the new building was then placed, which, with the exception of brick walls, virtually completed the erection of the new structure over the top of the old building. Two more bays of the old power house building, beginning at the south end, were then taken down. The mill building columns were reinforced on the drive side and the new crane girders for the crane to serve the new drive, erected in two days. A 75-ton open hearth pit crane, which had been overhauled and converted into a single hook crane to serve the motor drive building, was next placed on the runway in the two south bays, and a fourth bay of the old building taken down, which permitted the further erection of another or third bay of the new crane runway girders. This procedure was carried on until the entire building was removed and the complete new runway erected. The engine was, in this manner, at all times covered by either the 75-ton crane of the new building or the 10-ton crane of the old power house, or both if needed in the bay between them.

The tearing down of the old building and subsequent erection of new members was done under cover of the roof of the new building, while the engine was operating on regular mill schedule. Use was made of the new roof trusses above for fastening rigging used in dismantling and erection. Following this, the laying of brick for the east and south walls was started and long with the south wall the erection of the switchboard gallery, which was followed by erecting the switchboards and connecting wiring. Meanwhile, foundations for the north wall of the drive room were put in and the concrete work for the underground air ducts completed as far as possible.

*Chief Engineer, Donner Steel Co., Buffalo, N. Y.

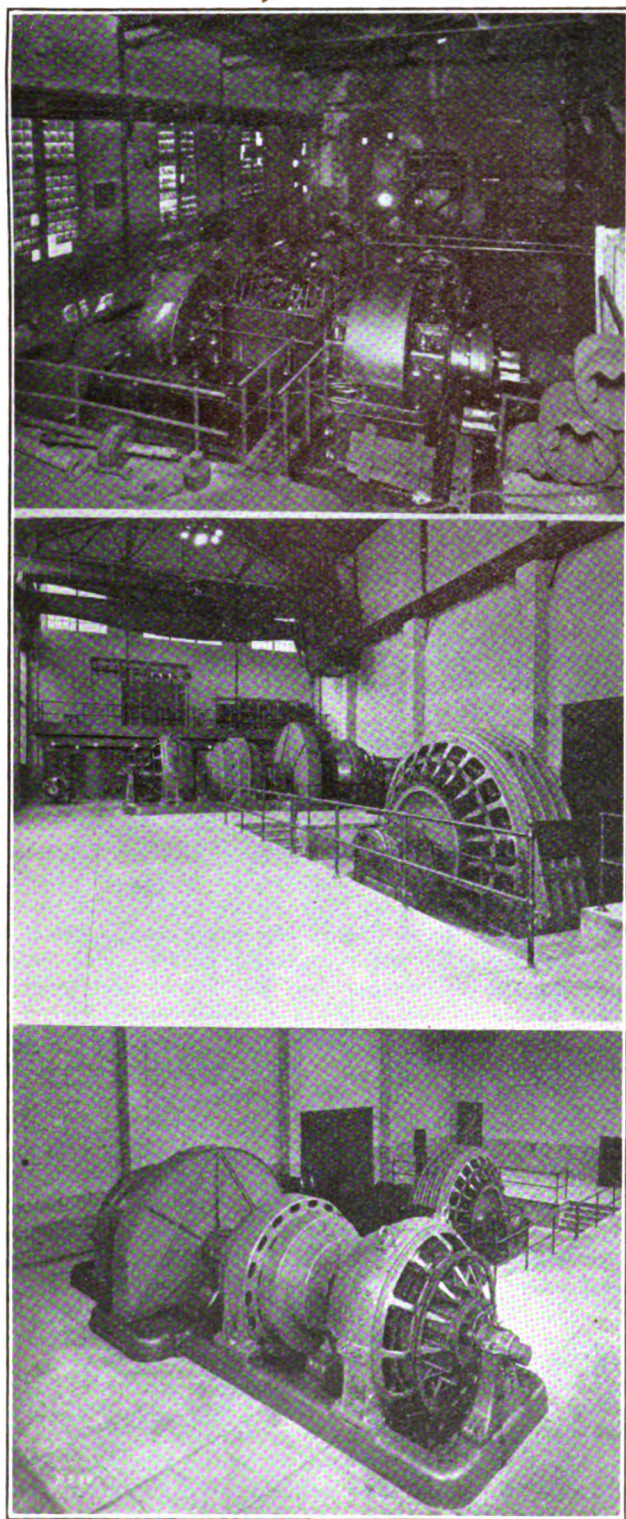
The new work up to this point was carried on around and over the top of the engine while operating, without a single shut-down, except for the regular Sunday cessation of operations. The construction work was carried on under more or less difficult con-

bracing of forms for concrete, scaffolds and various members of the building, while under construction. There were no switching tracks near the site to facilitate handling materials. A very limited amount of space across the end of the building and along one side of it was available in which construction work could be carried on.

Every preparation was made for the final shut-down in order that the change to the electrical drive could be made in the shortest possible time. A temporary construction track elevated on a trestle across the north end of the drive building, between the engine foundation and the north wall, was placed a few days before the mill was shut down, so that it could be quickly connected to a temporary spur track, also placed at the same time, across the mill from a track in the mould yard. This track was placed across over the mill tables while the mill was shut down. The trestle was provided in order to make the north end of the engine foundation accessible for dynamiting. A Leyner concrete drill sharpener and a tempering furnace were temporarily installed near the site to keep the drills in good condition at all times. Lumnite cement was procured to expedite the foundation work.

The engine with its auxiliaries and steam piping, weighing nearly a million pounds, was dismantled and removed completely in 22¾ hours after shutting down. Drilling and dynamiting of the engine foundation for new foundations for the motor generator set and reversing motor was started simultaneously. The motor generator set being placed across the south end of the engine foundation sufficiently far away from the reversing motor, permitted concentration on the foundation for this set, so as to enable its completion earlier than the foundation for the reversing motor. Erection of the motor generator set was started seven days after shutting down. This was followed by completing the concrete work, which was mostly poured with Lumnite cement, for the exciter set, slip regulator, conduit tunnel between switchboard basement and motor generator set, and for the buss bar collar between motor generator set and reversing motor. The foundation for the reversing motor was next completed. This permitted the starting of erection of the reversing motor; 12 days after shutting down. The wiring, together with setting up of auxiliaries, was carried along as rapidly as possible, in order to permit turning over and adjusting the main units as far ahead of starting as was possible.

In preparing the foundation for the reversing motor, the engine foundation was dynamited out to a depth of about 11 feet. Structural beams were anchored at this elevation into the remaining existing foundation below, by six of the engine foundation bolts, which were shortened for this purpose. These extend into the existing concrete to a further depth of about 10 feet. Eight of the motor anchor bolts, not including the four principal bolts at the drive and thrust bearing end, were secured to these beams for bolting down the motor. The four bolts at the drive end bearing were anchored down through the new concrete into the old engine foundation below and fastened in the tunnels of the old foundation at a depth of about 20 feet below the motor base. The new concrete for the reversing motor foundation was poured of Portland cement up to about 15 inches of the top and finished up with Lumnite cement concrete. This was also done with the foundation of the motor generator set. The aim in doing this was



Upper, shows the former mill drive, a 48"x60" simple steam engine. Middle, view of the 4,000-hp. G. E. motor recently installed. Lower, shows the motor generator set.

ditions. The engine, being badly out of balance, put in vibration everything around it to such an extent as to make it necessary to stop certain parts of the work at times, and to require more than extraordinary

to obtain a sufficiently hard surface to permit erection of equipment in the shortest possible time after pouring of concrete was completed. Erection of the motor generator set and reversing motor was started about 26 hours after their respective foundations were poured.

The mill machinery was completely overhauled during the shut-down, including certain changes in the roll stand to enable the use of larger blooming rolls and new universal spindles between pinions and mill. The pinion housing was machine altered for new pinions of larger diameter, and equipped with new bearings designed for lubrication by splash from the pinion teeth. The pinion teeth, bearings and universal ends of lead and mill spindles are lubricated by oil from the bath in pinion housing, into which the pinion teeth dip. A new operator's pulpit was erected in place of the old pulpit used with the steam drive. This pulpit is of plate and structural steel construction, and is entirely enclosed. Steel sash with clear wire glass enclose three sides of the pulpit with bullet proof plate glass extending across the entire front, to give a full view of mill to the operatives and at the same time offer protection from flying scale. The pulpit is ventilated by washed air from the air washers.

The reversing motor consists of a single unit shunt wound machine operating on 750 volts d.c., having a speed range of 0 to 120 rpm. in both directions and having a momentary torque capacity of 1,050,000 pounds feet. Its continuous capacity based on 50 deg. C. temperature rise is 4,000 hp. It is direct connected to the pinion housing of the mill through a universal lead spindle. The motor is semi-enclosed and ventilated by washed air.

The motor generator set consists of two 1800-kw., 50 deg. C. rating, 750-volt, d.c. shunt wound generators in parallel, driven by a 3,000-hp., 50 deg. C. rating, 500-rpm. synchronous speed, 2200-volt, 3-phase, 25-cycle, slip ring induction motor. A 40-ton flywheel is mounted between the induction motor and one of the generators, while the other generator is direct connected to the motor on the opposite end. These units are all supported on a common base plate and are all semi-enclosed for the purpose of forced ventilation by washed air, with provision for self ventilation when required.

The excitation for the d.c. generators and reversing motor is furnished by a 100-kw. motor generator set running at 750 rpm. Three 70-kva. single phase transformers with 115-volt taps for starting are used in stepping down the 2300-volt current to 230 volts for power on the auxiliaries. A liquid slip regulator is used for automatically regulating the amount of resistance in the secondary circuit of the induction motor to permit an exchange of energy between motor and flywheel. This regulator is arranged for use in starting the set and for dissipating the slip energy. The remainder of the auxiliary electrical apparatus consists of the necessary oil switches, automatic switching equipment, instruments, breakers, etc., for the complete installation.

Washed air is furnished by two air washers each having a capacity of 30,000 cu. ft. of air per minute. Normally one washer furnishes air for the reversing motor, while the other is used in ventilating the motor and generators of the motor generator set. Provisions have been made, by interconnecting the air ducts leading from each of these washers, to permit of

the use of the washer normally on the motor generator set for ventilating the reversing motor in case of trouble with the other unit. The washers, fans and pumps are located in No. 1 Power House, just outside of the motor drive room, and are arranged to take in outside air or recirculate air from the motor room or both, as desired. The starting controls for motors driving the fans and pumps are interlocked with the main starting control on the large units, so that the latter cannot be put in operation without forced ventilation.

The bearings on the reversing motor and motor generator sets are ring oiled; supplemented by a gravity oil circulating system to insure ample and fresh oil at all times. The flywheel and reversing motor bearings are arranged and piped for water cooling in case of emergency.

The switchboards and equipment are placed across the south end of the motor drive room. The low voltage starting, contactor and instrument panels for the reversing equipment, together with automatic switchboards for the mill auxiliary motors, are on the main motor drive room floor. The high tension oil switches are placed on one end of a gallery over the switchboards. The d.c. resistance mounted on racks is placed on the other end of this gallery. The 75-kva. single phase transformers and a series transformer are placed in a cellar under the switchboard as a protection against fire in case of the loss of one of these.

The operation of the reversing motor is entirely in the hands of the roller through a manually controlled master placed in the pulpit. This master, together with a single similar master controlling the approach and delivery tables on the mill, is so placed as to enable him to operate the mill and tables with his right hand. Another similar master conveniently placed gives him control of the screw down with his left hand. The manipulator is hand operated from the pulpit by another operator. This arrangement allows the operatives freedom in operating the mill in either a standing or sitting position and makes possible the operation with two men, where formerly three were necessary.

The equipment has an estimated monthly capacity in rolling 21½-in. square ingots into 4x4 in., 5½x5½ in. and 9x9 in. blooms of 35,000, 50,000 and 62,000 tons, respectively.

The complete electrical equipment was furnished and erected, including wiring, by the General Electric Company. The new universal spindles, pinions and bloom rolls were furnished by the Mesta Machine Company of Pittsburgh. The structural steel for the building was furnished and erected by the Lackawanna Steel Construction Company of Buffalo. The necessary piling was driven by the Great Lakes Dredge & Dock Company of Buffalo. All other work, including the rearranging of equipment, dismantling of engine, foundations, brickwork and miscellaneous work, including engineering, was executed by the organization of the Donner Steel Company, Inc.

1816—1926

The Townsend Company, manufacturers of rivets, nails, wire and wire products, takes pleasure in announcing as the oldest wire mills in America, its One hundred and tenth Anniversary.

CURRENT REVIEW

The Little Red Ball

The Story of Good Wrought Iron

By DONALD WILHELM

THIS surprising red ball of fire appears in the distance like a gigantic fire-fly. It hovers for a moment, just as night is settling down, at the end of a long aisle, in the dusk of this cavernous building.

Then it comes forward.

Ever so evenly, like a meteor defying the law of gravity, it comes rushing toward one, as if propelled



FIG. 1—The little red ball.

by its own heat and power. Not until it is near at hand do you see that behind it, holding it, pushing it, at the end of long tongs supported by chain and pulley on runway overhead, is a giant of a man.

A puddler! Nearly 200 of them work in this mill, the largest of its kind.

Now, down another aisle, comes another.

Along all the outrunning aisles of this busy scene they come, each bearing his ball of fire. Yet there is no confusion. Like men bearing offerings to Mars and Vulcan, in orderly procession they emerge from all the reaches, all the recesses of this big area. They pass, then return.

There comes the shriek of a whistle. Now there is a pause in these pilgrimages. Yet the explosions that you heard, blocks away, continue, near at hand.

The whistle shrieks, reassuringly. At once, everywhere, the movement is resumed.

Still the explosions go on.

Of course, as soon as you have caught the picture of this scene as a whole, of these giants with their dripping balls of fire, of small furnaces like bakers'

ovens on every hand, of huge waste-heat boilers standing on end atop them, reaching up into the dim tracteries of pipes and steel girders overhead—then you want to know the cause of those explosions.

So our guide takes us to a central place, the end of the journey and the rendezvous of all those giant puddlers.

Here, in a cleared space, is a kind of steam roller heavier and bulkier by far than any seen working on asphalt streets. And it isn't puffing and backing and filling. It is busy enough when staying in one place, where its ponderous drum revolves on an axis that is vertical, not horizontal. And its water-cooled shell is open at the front.

Into the front, the maw, of this big and hungry machine, the puddler, each in his turn, thrusts his dripping ball of metal. Metal teeth grip it, revolve it ought of sight, drawing it into a throat, water-cooled, that grows smaller and smaller. Where the pressure between the drum and shell comes hardest on it, its gases are expelled. The cooling water strikes it, and explosion follows, a reverberating protest by the metal, it seems, against this affront upon it.

The explosion is harmless, even beneficial!

The giant who ministers to this huge squeezer, or wringer, does not seem to mind this gunfire. He wears goggles and a heavy mask falling to his chest to protect his face, a heavy leather apron to protect his body, and his shoes are protected, too. Now and then he dips his hands into a nearby bucket of water or gives over one pair of tongs for another that is cool.

With these tongs, as the red blocks of metal, now compressed, topple out, like huge bricks falling against one another, on the metal platform where he works on his short shift, he plucks one up and sways it over to a mill before him—a 3-high set of rolls.

He starts it, sizzling and protesting, between two of these rolls. Men on the other side receive it, lift it, play it back, between the upper rolls.

He returns it once more, starts another, with continuous motion and the ease of experienced skill keeps clear the space before the squeezer, keeps those red shapes of metal writhing back and forth through the rolls.

At last, flattened out, still hot but rapidly turning to a dull and unprotesting bluish gray, the fire in our red ball is ironed out. Now the meteor, that red ball of ours, is an elongated strip, like a ribbon made of metal. Now, on the other side of the rolls, it moves on rollers, to a cooling platform.



FIG. 2—The Pittsburgh plant of the Byers Company, with the Monongahela River in the background.

Now, it is called, in the homely, intimate lingo characteristic of the wrought-iron mill, muck-bar.

Our two giants, the puddler, and the big fellow attending his squeezer and rolls—these two men dominate this spectacular industrial scene.

They are the key to the distinctive methods used in manufacturing wrought iron.

Supporting and supplying them, as a hundred men behind the lines supported and supplied each dough-boy at the battlefront, or fashioning their product to the insatiable needs of Man, is an industry whose origin lies in the buried past of the earth. It is older than any other in the metal world, older perhaps than any other industry whatever, and in its traditions older still. Its product has been of more importance to the progress of mankind; historically has been far more precious than gold.

To understand how, and why, wrought iron is made, and why, at last, it is re-establishing itself, is wrestling back to itself the oldtime prestige that steel, not long since, stole away, one has only to keep one's mind on these two giants—the puddler and the busy fellow ministering to squeezer and rolls.

Steel vs. Wrought Iron.

It has been, in a way, a gentlemen's game—the goodly struggle, during the last generation, between the masters of iron and of steel. There has been in it a singular genius of organization, and diplomacy, fine moving, the gloving of hands, the iron impact of battle,

with quarter neither asked nor given. On one side has been, and is, a Titan, beneficent and square-dealing enough, but in all ways powerful past words—a Titan answering to the huge needs of birth and replenishment of our Steel Age.

On the other side were—and are—smaller production, higher costs, a conservatism inherent, it seems, in the singularly interesting and close relationship between men and wrought iron as reflected in the manipulation of puddling furnaces—a close human relation like that of the blacksmith to his glowing forge.

Still, there is always the greater romance in a losing venture that wins in the end.

Away back, long, long ago, even before the Pyramids came to be, somewhere, on some primitive battle front perhaps, some man, or there may have been two, discovered the witchcraft of wresting ferrous metal out of the lap of mother earth. Then, someone discovered that if on a bed of embers was sprinkled a layer of red earth or pieces of out-croppings of hard rock that we call ore, that if more embers were heaped on this ore and one blew well upon it, in a little while a lump of incredibly hard substance was the surprising and useful result. Through all the ages before Nature had been doing her complex part preparing this ore for the needs of men. And through all the years since the first iron masters squatted before their fires to make the first iron, until just the other day—

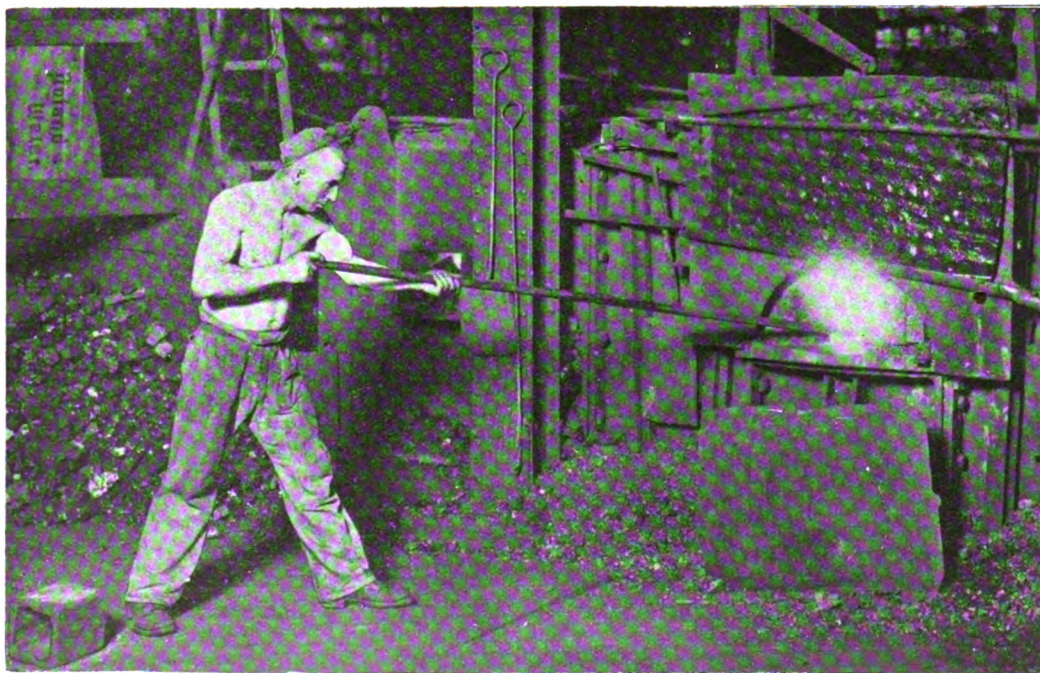


FIG. 3—A puddler engaged at his arduous task.

as centuries go—iron was the thing.

Then came those instrumentalities that permitted the production in quantity of steel.

For more than half a century now, ever since the Bessemer furnace was first used successfully in England in 1855 and the open-hearth furnace in 1861, steel manufacturers have sought to supplant the much older metal, wrought iron. Time itself—nothing else though—could decide an issue so momentous as this. . . . Time, it seems, is now lending a hand to wrought iron. . . . Without question, in its distinctive field, wrought iron is winning back its laurels, regaining its old-time prestige, regaining its place in the sun. It was in the '70's, when wrought iron still dominated metal production in the United States, that the first Bessemer and open hearth furnaces were set up here.

New and incomparably rich ore beds had been explored in Minnesota. New methods of production in quantity came to be. And with these new ore beds, these new methods, came the lure of low production costs, big tonnages, big business, and big profits. Over to the making of steel accordingly went many of our established masters of wrought iron. One by one, as the years went by, and the competition of steel undermined wrought iron, they junked their puddling furnaces, substituted Bessemer or open hearths or both for them, added their strength and skill to the conqueror, steel.

So steel became the thing!

And all manner of factors operated to accord it appropriate power and glory.

Steel was the big news in the ferrous world. Thus, its very advent was news. Its swift and surpassing development in point of organization, methods, ever-increasing tonnages—these were news! Its own expansion, you see, served the needs of exploitation!

But wrought iron was an old, old story.

Simply, steel meant what the making of good wrought iron could not mean—it meant the unprecedented phenomenon called quantity production. That phenomenon seemed the nemesis of wrought iron.

Wrought iron implies, necessarily, as we shall see, the use of the puddling furnace. It meant, and means, careful "handling" of small amounts of metal—not more or less automatic treatment of heavy tonnages of metal. It means a high labor cost. At date what is paid puddlers alone for each ton of good wrought iron they make, more than pays—pays nearly twice over—the total cost of converting pig iron into a ton of commercial steel.

A Bessemer furnace is a gigantic big-bellied roaring cauldron in which, under high pressure of driven

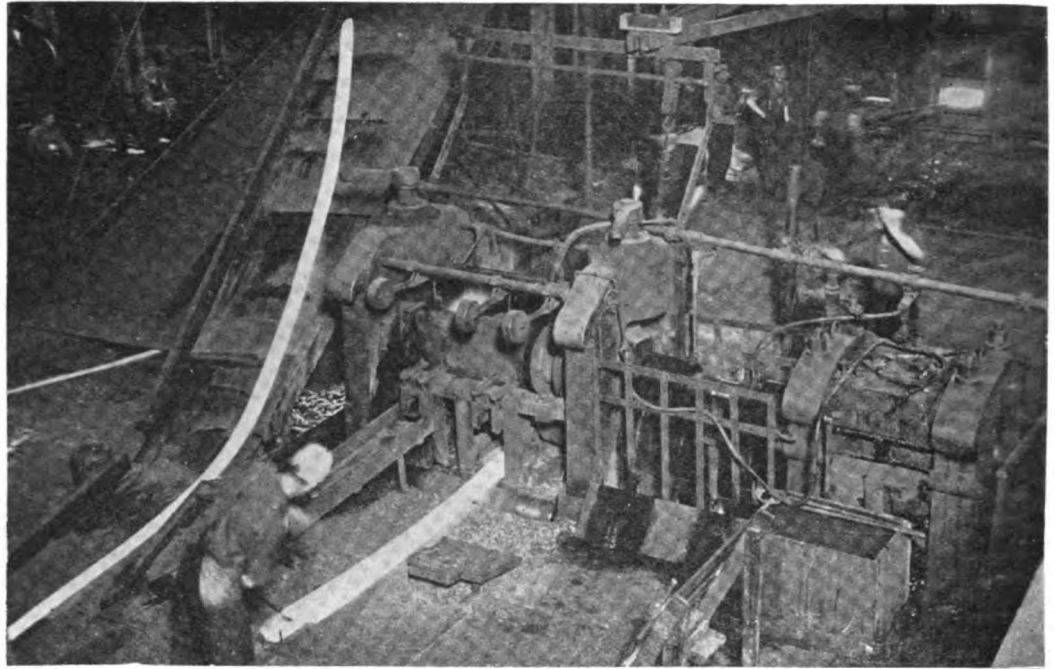


FIG. 4—Muck bar being rolled into skelp, from which pipe is made.

air, 15 tons of pig iron, brought in liquid form direct from blast furnaces, is refined in 15 minutes!

A Bessemer, with its ton to a minute, is operated by a few men in pulpits at the far end of an exciting arena, who control it with a few hydraulic levers.

An open hearth furnace is a large pool holding from 50 to 250 tons of molten metal which is liquid at start and finish, and, like the product of the Bessemer, is drained into great ladles which sweeping overhead cranes pour into ingot molds.

An ingot, the unit or dollar in measurement of steel production, weighs, typically, three tons. Your steel master likes to work such big units in his quantitative reduction or rolling of section.

But the charge in a puddling furnace—the charge from which three balls of fire are made—is only about 560 pounds!

Simply, a Bessemer or an open hearth is to puddling furnace what a thousand army kitchens, preparing rations for the whole A. E. F., are to a small kitchen stove.

A Bessemer or open hearth cooks tons!

Your puddler prepares mere pounds.

So, presuming that steel products—steel pipe, for instance—could do the work of wrought iron, it was natural, logical, even reasonable, for the steel masters to want their products to supplant wrought iron. It was stubborn, as they saw it, for an iron master to shake his fists at economic law and swear by all that is holy, "I'll make good wrought iron, or quit!"

And he didn't quit.

A. M. Byers.

Nor did he adulterate his product, wrought iron pipe, as literally every other remaining manufacturer of wrought iron pipe had, toward the end of the century, to do.

He shook his fist. He swore, delightfully—it's an impressive matter of record!—that he'd make good wrought iron pipe or "bust"!

And he didn't "bust"!

By and by Steel, itself, sought to buy him out. It argued naturally, logically, reasonably, no doubt!

His immediate answer was logical, reasonable, and natural, no doubt!

A spare and wiry little man, Scotch-Irish, stubborn and fiery all through—well, the making of good wrought iron was a matter of principle with him!

An eldest son, a young iron-monger who had served his apprenticeship in the metal industry, near Pittsburgh, at precisely \$75 a year, he believed in wrought iron! In 1864 he had, with associates he later bought out, taken over a blast furnace, built puddling furnaces and set to making wrought iron pipe. He thrived through the succeeding years while running a one-man business.

In that business he made all decisions. He "hired and fired" and knew his men, every one. He, himself, superintended his plants and their production. And being partly Scotch he paid spot cash for the equipment, material, and services he bought and took receipt therefor!

Stern he was, but, though highly energized during an eight-hour day (eight hours in the morning and eight past noon!) he was extraordinarily devoted to his family. Thrifty, too, a natural trader; yet he would pay any price for a good 2:30 trotting horse to drive from his home to his office, from his office over the Smithfield bridge across the Monongahela, to the South Side plant where his wrought iron pipe was made. Incidentally he was judge, except on Sundays of course, of trotting races on a track near Pittsburgh.

A good judge of horses is a good judge of men! So the saying is.

He, himself, selected the horses used in the early days of his one-man business when his South Side plant had no railroad connections, was serviced only by horse and wagon, with pig iron carried one way over the bridge and the finished product back. One day one of the foremen asked that a large quantity of pig iron be transported to the plant before winter closed in. "I'll be hanged if you get another pound of iron!" he roared.

But soon he sent much more than was asked for.

He was like that—he liked to mind his own business!

When, toward the end of the last century, the competition of steel was sorely felt on one hand and labor troubles were beginning to bristle on the other hand and other troubles only gave him new zest for the game, usually he kept his plant continuously running, even all winter. Often, in the spring, his yards were full of pipe. Then, with a piece of pipe under his arm, as it were, he made off—he, himself, was his only traveling salesman—to see the half dozen jobbers who handled his product. Sometimes, one now reports, they fought with him over prices and the like; he loved them for it! Still more to his liking, they who had known him and his pipe for many years, took all he had to offer.

It was along in the early nineties, and steel, with bigger production than ever, was steadily tightening the pipe market, when one of his few jobbers sent word to him—in substance this:

"Steel pipe nowadays is the thing! I can't sell any other. It's getting cheaper and cheaper—they



FIG. 5—Typical scene near the finishing end of the pipe mills.

say it's better, too. Tell 'A. M.' he'll have to make steel pipe or bust!"

And "A. M." didn't bust!

One of his associates, one of those who carried on for him after his death in 1901, put before him, one dreary and uncertain day, some facts that were disturbing.

Already he had sunk a lot of his own money in his business. Now he nodded. "I know it," he said, "we're in a tight fix!"

Still he didn't quit!

Instead, on one occasion at least, he sent out a hand-written letter—he used no typewriters as yet—to the trade, in lieu of advertising, it seems.

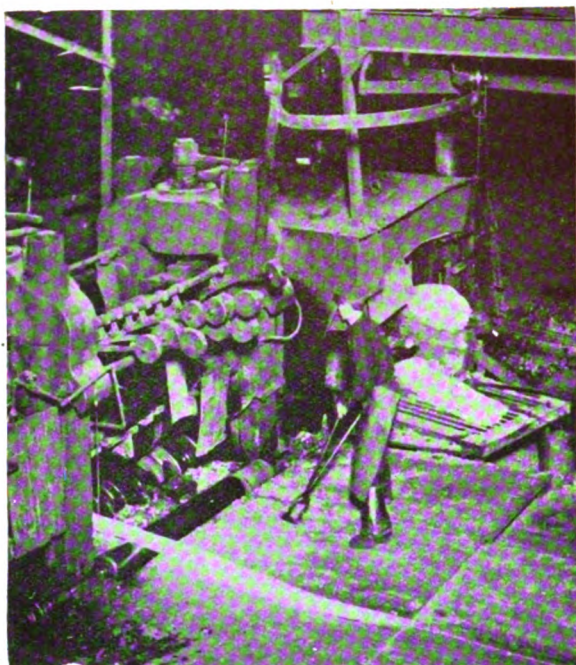


FIG. 6—"The giant at squeezer and rolls."

Here is that letter, which was dated February 1, 1894:

"With the gradual decline in prices of pipe for some time past, nearly all of the manufacturers have cheapened their product by making steel pipe and light weight.

"The steel necessary to make pipe can be produced at from \$5 to \$7 per ton less than good soft iron such as we use in the manufacture of our WROUGHT IRON PIPE.

"Manufacturers of steel pipe may represent it as good as iron pipe, but a trial will convince those who have not used it that such is not the case.

"It is next to impossible to get a uniform quality of steel, as from one lot there may be found a few pieces of pipe that will work satisfactorily, while others from the same lot will be so carbonized that tools will be ruined in the cutting and threading process.

"In most cases, steel is shipped out as iron pipe and the buyer only discovers the difference after an expensive trial in cutting and threading the same.

"We adhere strictly to standard weights, and are probably the only exclusive manufacturers of

WROUGHT IRON PIPE in this country at the present time.

"We therefore feel that it is due to you and just to ourselves to advise you, as above; and we respectfully solicit your orders for our FULL STANDARD WEIGHT WROUGHT IRON PIPE."

The capitals all are his!

It seems both important and interesting to get this glimpse of the man—he who ran a one-man business against big business—and made a profit to boot!

The organization he founded has grown in all ways, has doubled—has trebled—its production, during the last generation. And while it was doing that, practical business men who had thought that wrought iron was vanquished for evermore now fell to wondering. They shook their heads dubiously at first. "It can't be done," they said. "Wrought iron can't come back!"

But wrought iron did come back, and when at last the spirit of A. M. Byers did win through, then these practical business men rallied, as it were, with the good old fighter for wrought iron. Back to wrought iron came some steel men and some outside business as well. Interested, they brought offerings of what they had in energy, brains, and money.

Now the two great Byers plants produce fully half of all the good wrought iron pipe made in America—more than 40,000,000 feet a year.

And, more important still, in its plants, in the organization on the merchandising side, and in its laboratories, it has built up and sustained a fund of knowledge and experience pertaining to good wrought iron which is not, I am reliably told, duplicated anywhere else in these United States.

A kind of story-book character he was—he who fought a losing cause and won—a kind of hero quite in keeping with the early traditions of wrought iron.

That is one reason why, when I wished to see why and how good wrought iron is made, I wanted to go to the Byers Company, to its main offices in Pittsburgh, its plants there and in Girard, Ohio.

Rust.

Obviously, Mr. Byers believed implicitly in good wrought iron. Obviously he had that pride in his product that was characteristic of a manufacturer whose life is, in a sense, his business itself. But why?

With seeming enjoyment why did he seem to defy every rule of common sense, every dictate of economic law, just to be a lone sentinel guarding the destiny of good wrought iron pipe?

Why is it, in other words, that though steel pipe can be made in miraculous tonnage, with miraculous speed, and puddling is a slow and laborious process, still, with powerful and huge handicaps put upon it during the last generation, wrought iron has, nevertheless, for certain uses, triumphed over steel?

By way of answer:

Good wrought iron cannot even now be made, except by puddling.

In no other way is refined iron ore—pig iron, as it is called—made so well to answer to the needs of effective and enduring welding. In no other way is any commercial ferrous product made to afford such

good threading qualities. In no other way is iron made so resistant to vibration and "fatigue."

But mainly—and in this Time alone was the arbiter—in no other way is ferrous metal made, when used in pipe, for instance, twice as enduring as commercial steel in resisting the silent, treacherous, relentless arch-enemy of all metallic things—corrosion—or rust.

Rust, like age in human beings, is inherent, in measure, in metal. It is catching, too! It is contagious and infectious both. It has innumerable allies all at work together to reduce Man's refinements of Nature's metal products to Nature's original, stable forms. Rust, in a word, is decidedly aided and abetted by an endless array of varied and changing factors and considerations. It has vagaries and contrarities and it does unpredictable things, like germ life itself.

And, accordingly, it levies on modern civilization an annual tax comparable with that of disease itself.

In some circumstances, like those occasionally found in some coal fields for instance, metal goes down before corrosion in a few weeks. Nevertheless, it was only the other day that a pipe line near Pittsburgh was taken up after doing service for 30 years, and its good wrought iron is, according to the report of the oil expert in charge, as good as ever.

In many instances, metal resists the ravages of rust but a few months, or a few years.

There are specimens, to be sure, which are said to be more than 5,000 years old. The Pillar of Delphi has stood for upward of 1,600 years. Ancient specimens from India are cited as having endured for more than 500 years. And in this country the Newburyport Bridge, which was taken down after being in use for a century, is often cited as a standard example of the long life of metal made before the Bessemer and open-hearth processes came into use.

It was relatively easy, in the day of small buildings, cheap labor and few if any internal plumbing fixtures, to replace the pipes in a building or to replace the building itself. But the Steel Age brought with it the means to build cathedrals, sky-high, to serve as offices and homes. Now a modern hotel building like that of the Pennsylvania Hotel in New York City has built into it approximately a hundred miles of pipe, and the Woolworth has more than 50, nearly all of which is Byers, by the way. Now you see, with the complexity and permanence of modern construction, it has come to be the part of wisdom to use good wrought iron pipe. Though it costs more than steel, the initial cost is pleasurable when prevention of rust forestalls the agonizing business of replacing pipe.

"Steel pipe," R. M. Starbuck points out in his authoritative book, "Modern Plumbing," "is much used"—and paid for—"in place of wrought iron, many times indeed, under the impression that it is wrought iron. . . . Steel pipe should never be used."

Because they build for permanence as well as utility, nowadays architects and investors demand greater longevity in pipe than ever before. Buildings, like men, they say, are as old as their arteries! There is, they explain, a disease affecting human beings called arteriosclerosis. It means that the walls of one's arteries prematurely harden. It is a mark of age.

Buildings, too, suffer from arteriosclerosis! That is why the Metropolitan Life Insurance Company and many other companies which are scrupulous about the longevity of their investments, have laid down as their invariable policy that good wrought iron pipe shall be used in preference to steel in all the buildings they underwrite. "In the smallest house that we build in Astoria as well as in a large apartment or office building," the Metropolitan permits me to say, "we insist on good wrought iron pipe. This policy was long since established as the result of extensive experience. Just why good wrought iron pipe outlasts steel pipe is, for us, more or less beside the point. We know that it does. The fact that it does—that experience and professional observation demonstrate that it does—that is enough."

One of the company architects took up a small hinge from a table. "Look," he said, "at the rust gathering on this, in the dry atmosphere of this office. Here now is a window pulley just as badly off. Details like this help to fill out the picture that we get by experience. Not long ago, at the head of Mattituck Creek, on Long Island, I struck an old mill. It is nearly a century old, but its hand-made shingles are still held securely in place by good wrought iron hand-made nails. These nails are much longer, because the shingles are thicker, than the nails now used. When removed they look good for another century."

"At the site of Saint Pierre, on the island of Martinique in the West Indies, by the way, I found another interesting illustration of the resistance of wrought iron to corrosion. On this island is the ruins of the old house where the Empress Josephine, Napoleon's wife, was born. Saint Pierre was the largest and most flourishing town on the island. In 1902 it was totally destroyed, and nearly 40,000 people were killed, by the eruption of Mount Pelee. On the beach, exposed to high tide, spray, moisture, and sand, half buried in volcanic scoria, I found a ship's anchor chain of good wrought iron. They used to drag an anchor chain up the beach and secure a vessel that way, because the water is very deep. That chain was still in good shape, though the intense heat from



FIG. 7—An artist's conception of pipe welding.

the eruptions had in places turned the metal blue. Not much else, if anything, survived that disaster and the ravages of corrosion."

When Colonel Goethals and his associate builders of the Panama Canal tackled their gigantic task, they found—this also is a matter of record—wrought iron roofing and other wrought iron left by the French, which had resisted the ravages of the tropics when nothing else had.

The other day, a country gentleman in Pennsylvania reported that though his ancestral country house had been standing for generations, its good wrought iron eave troughs and leaders were as good as ever. But twice, in six years, he had replaced steel troughs and leaders on an extension!

And you, yourself—to go no further with thousands of available examples—may, on tearing down an old building, have found good wrought iron nails that were driven long ago. And, you find, they still go on doing service, though steel nails, driven in long after wrought iron nails ceased to be available, have rusted out.

The Mission of the Puddler.

Good wrought iron has a greater capacity for resisting rust than steel. In that fact lies, the supreme reason why wrought iron survives, though, a generation ago, the Bessemer process of itself, "made possible at once the increase of 100 fold in metallic production," and brought with it hardness, cheapness, quantity, large organizations, every facility and device on both the selling and manufacturing sides to supplant wrought iron. Nevertheless, wrought iron, centuries old, still competes in certain fields with steel, which came of age in a single generation.

Oddly enough, wrought iron, in resisting rust, has also resisted steel, which cannot resist rust so well.

And good wrought iron resists rust essentially because it is prepared for use, unlike steel, by puddling.

Puddling constitutes the one distinctive contrast between the making of steel and of iron. Until the puddler goes to work "handling" his metal, the product is the same. For both start with pig iron.

In steel mills the molten pig iron is poured into ponderous ladles and carried, in liquid form, to Bessemer, open hearth, or electric furnaces.

In these furnaces—and in the puddling furnaces, too—the essence of the refining process is the burning away or melting out of the impurities from the pig iron.

As the pig iron is brought from the blast furnace it contains, typically, about 4 per cent of carbon, $\frac{1}{2}$ to $1\frac{1}{2}$ per cent each of manganese and silicon, some sulphur, some phosphorus. These ingredients are called impurities, or metalloids, though carbon in limited quantities gives strength and hardness and manganese gives toughness to steel. In the steel industry the percentage of these ingredients can be regulated best in the electric furnace, which is necessarily small; next best in the open hearth, least of all in the Bessemer. The Bessemer provides most of the steel from which steel pipe is made.

In each of these cases the percentage of these ingredients must be regulated in the steel industry—but not in the making of good wrought iron—by additions in desired amount of carbon, manganese and other elements, at the end of each heat, with results that we shall see. But, first, before this doctoring—

and what follows is very important in our contrast between steel and wrought iron—as the temperature of the molten metal in the steel furnace is raised from 2,100 deg. F., say (while slag is quickly forming a blanket on top of it), its fusion point steadily rises as its carbon is burned out and decreased. By and by, when the metal is what might be called pure iron, the temperature of the fusion is between 2,700 and 2,750 deg. So long as the temperature is held at that point, the material under the many-tinted bubbling blanket of slag is in fluid condition. On the other hand it is sufficient to say that if the temperature of the furnace is reduced to 2,600 deg., say,—there is a stage in the fusion where the material as it solidifies will steadily settle to the bottom.

In the early stages of puddling, long ago it was not possible to keep the refined metal in a state of fusion; so it solidified. The old-time iron makers, accordingly, kept their mixtures refining as long as they could by stirring, or rabbling. This circumstance so fortunately taught mankind the value of wrought iron that the method then necessarily pursued is continued, to date, in the puddling furnace. That is why, whereas in steel the materials used are not touched by human hands from the first time they are gouged out of the lap of mother earth until they are eventually fashioned, in the wrought iron industry we have the anomalous intimate human element, the actual handling of metal, in the puddling furnace.

And why?

Because, in the steel furnace, since both the slag and the refining metal are liquid and the slag floats atop the metal, the two are not intermingled and cannot be made to intermingle any more than oil can be made to intermingle with water. And, when the charge is poured, still the slag and metal are separate. In cars or little cinder buggies the slag, sloughed off, is carried off to dumps.

But in the puddling furnace part of this slag becomes intimately mixed with the iron, imparting to it characteristic virtues.

A puddling furnace is small in contrast with a steel furnace. It is a little fire-brick oven in which heat is generated by soft coal or gas. This heat passes over the ore bath very much as heat passes over the oven in a kitchen range.

The oven is carefully prepared for each heat. Thus, with their hand tools, you see the puddlers working in pairs, tamping raw red ore over the fire-brick within.

In it, as the cold pigs of iron melt and become a bath, agents are added to facilitate the formation on top of it of a blanket of slag—slag of just the kind desired. Thus pure iron oxide instead of dolomite or burnt lime is added because it functions better and does not interfere with subsequent welding, yet it costs six or seven times as much as lime. Now little by little, the carbon, manganese, sulphur, and phosphorus and other undesirables are effectively removed—all of them oxidize or burn preferentially to iron. And meanwhile the puddler, one of two men attending each furnace, gets to work. He sets to work—and works continuously—to see that the slag and the refining metal do intermingle. Through a small aperture in the small iron door of his small furnace, in his cauldron heated by coal or gas flame, he sets to work as soon as his cold pigs of iron are fluid. He

beats that mixture, whips it, stirs it, kneads it. His long rabbling tool gets too hot to hold or begins to melt. He casts it into a vat of water and continues with another. He is "the picturesque baker, the pastry cook, the mighty chef. All that follows, the whole pudding, the quality of the iron to the end of its life, will be the test of his skill and daemonic impatience." And still to quote "The Cinder Buggy," he may be taken for a "sign that when Man refines beyond God's content with things as He left them will very soon perish from want of the dross from which it is parted!"

In other words, the function of the puddler is not only to refine the iron, but also to keep the slag in his furnace mingling with his metal.

Hence the puddling furnace.

Hence much anomalous hand labor in an industry where, everything else, machines are made to do the work of men. Hence the greater rust-resisting properties—the greater longevity of good wrought iron.

And why?

Because it is an established fact that slag, the scoria, the excreta expelled from the steel furnace, is nature's agent and man's dependable friend, in resisting rust.

Slag is an anti-toxin for rust!

Steel is a non-slag ferrous material.

Wrought iron is a slag bearing ferrous material.

In that simple and startling and everlastingly important fact lies the essential difference between the two metals.—World's Work.

The Story of Cold Drawn Steel

TODAY, very little bar stock is cold rolled. Nearly all of this material is cold drawn, although the term "cold rolled" is rather generally used. Some few manufacturers cold roll rounds over $4\frac{1}{2}$ or 5 in. diameter, but the general practice on large rounds, especially shafting, is to turn and polish. One company has built up an enviable reputation for shafting by turning and grinding bar stock. In this manner finished material of exceptional accuracy and straightness may be procured.

The big tonnage of cold rolled material is in strips. Some mills have specialized in this steel to the extent that they are supplanting special sheet automobile fender stock with strips.

Cold drawing or cold rolling may be employed to:

- 1—Secure accuracy of size.
- 2—To obtain a smooth, even surface.
- 3—To produce thin complicated sections.
- 4—Effect the physical properties.

Cold drawing causes permanent distortion of the crystal structure. There is no refinement of the grain as this cannot be accomplished below the critical temperature. Cold drawing accentuates banding. In some instances this is so marked that the end of a fractured piece has the appearance of a piped bar.

If cold working has not been excessive, the original properties can be restored by annealing. On account of the lines of weakness in gear teeth due to improper grain flow, most driving pinions are forged under a drop hammer or in a forging machine. Until recently they were turned from cold drawn stock, as are most automotive gears that are not subject to severe stresses.

When the bars are brought to the shop for cold drawing, it is first necessary to remove the scale. This is done by pickling. The solution used is 8 to 10 per cent sulphuric acid, of 60 deg. Baume. The chemical action is increased by introducing steam into the vats. The tubs are built of wood, and are generally about 30 ft. long by 4x3 ft. in section. The time of pickling will vary from $\frac{1}{2}$ to 2 hours, depending upon the character of scale to be removed. Pickling requires care, else pitting of the finished bars occurs. Sometimes heavy scale will be rolled into a bar in spots.

In removing the heavy scale, the rest of the surface is sometimes over-exposed to the acid.

After pickling, the bars are washed with water to remove the acid. Some shops use boiling water for this. After washing, the steel is transferred to a lime bath. This is a strong solution of water and slaked lime. The basic solution neutralizes the acid which may remain on the bars after washing. The practice in wire plants is to bake rods or wire after pickling. This is done in heated ovens which attain a temperature of 500 or 600 deg. F. The operation is a precaution against brittleness which may be caused by occluded hydrogen picked up from the acid.

The steel is ready for the drawing machines after pickling except for the pointing. Pointing is necessary to reduce the diameter of the rod or bar, so it can enter the die. This is usually accomplished by turning in a pointing machine.

Some shops hot swage large sizes, especially heavy flats. A special head equipped with grips is applied to some machines which forces the end of the bar through the die. This cannot be done with small stock, because it will buckle. Bars $1\frac{1}{4}$ in. however, and over can be handled in this way.

The dies are generally made of a special alloy tool steel peculiarly adapted for this work. It is very high in carbon, some analyses running as high as 2 per cent. A steel which shrinks upon hardening is desired so that the hole can be trued up to the exact diameter. Dies for rounds are solid; those for squares, hexagons, and flats are made up of sections, as are most dies for special sections. The Brinell hardness will run from 500 to 600, the harder die being desired for the smaller sizes. The life of a die will average about 25 coils on alloy steel wire sizes. On bars of 20 to 30 ft. in length the average will run about 500.

The drawing machines are horizontal benches, now driven by individual motors. The grip or jaws, which take hold of the pointed end of the bar, engage with an endless chain which draws the material through the die. For wire sizes or coils, two types of drum machines are used. On one, the axis of the drum is horizontal. This is used for the larger sizes of coiled stock from about $\frac{1}{2}$ to 1 in. It is generally called a

bull block. The drums for drawing smaller sizes from $\frac{3}{8}$ in. down have the axis of the drum vertical. These are the wire blocks. In wire mills, one operator may have charge of a number of drums similar to a shop operating automatic machines.

The draught or reduction per pass will vary with the size, analysis, and finish desired. The usual practice is to reduce the diameter $\frac{1}{16}$ in. on sizes down to $\frac{5}{16}$ in. Under $\frac{5}{16}$ in. the reduction is generally $\frac{1}{32}$ in. This applies to such steels as screw stock, 1015, 3120, 2325 and 6130, whether drawn in the hot rolled, annealed, or heat-treated condition. In some instances the reduction will be greater than $\frac{1}{16}$ in., at other times less than $\frac{1}{32}$ in. For instance, if a shop has $\frac{13}{16}$ in. steel in stock which is ordered for $\frac{3}{4}$ in. cold drawn material, it could be drawn to finish $\frac{23}{32}$ in. or $\frac{25}{32}$ in. This would be done only for small orders. Again, on very small sizes, since No. 5 B. W. G. rod is about the smallest size most mills

can furnish (.220 in.), it may require two or more draughts or passes to secure the finished size. In such instances it is necessary to anneal and pickle the material between passes, and the draught may be as light as $\frac{1}{64}$ in. per pass. A better finish is secured with a heavy draught. There will be less pitting if the reduction is heavier. This will decrease the drawing speed and hence the production, but the increased cost is warranted for specialties such as piston pin stock, etc.

The speed of drawing will vary with the diameter and the analysis or condition of the steel. The feet per minute for various steels will average about as follows:

	Alloy Steel Bars	Carbon Steel Bars
Diameter.....	$\frac{1}{2}$ - $\frac{1}{2}$ in.: $\frac{1}{2}$ - $\frac{3}{2}$ in.	$\frac{1}{2}$ - $\frac{1}{2}$ in.: $\frac{1}{2}$ - $\frac{3}{2}$ in.
Feet per min....	40 : 30-35	80 : 60-70
	Alloy Wire Sizes	Screw Stock
Feet per min....	30-35	160

—U-Loy News.

Uranium X—Its Extraction and Estimation

By RAJENDRALAL DE

URANIUM X as discovered by Crookes (Proc. Roy. Soc. A, 66, p. 409, 1900) is, at present, known to consist of four distinct substances viz., U_x , U_y , U_z , and U_w . The different methods employed by various investigators for its extraction are not very convenient for its repeated extraction in a large scale from a particular sample of uranyl salt. It was therefore thought desirable to search for a method suitable for such extraction.

During this investigation I had often to measure very feeble activities and I found, for this purpose, an electroscope with an aluminum leaf tipped with a fine quartz filament very convenient. The electroscope was arranged for measuring the β -rays only and all my measurements of activity have been carried out with its help.

In order to get an estimate of the quantity of U_x present in a uranyl salt I employed an indirect method. A certain amount of an old sample of uranyl nitrate, purified in this laboratory in 1921, was converted into its oxide U_3O_8 , the purity of the sample having been verified by the decay curve of U_x prepared from a part of it. Next with the help of the above oxide several films of U_3O_8 were prepared. They were of different thicknesses but had the same area. I shall state later on the method I employed for their preparation.

Now from a knowledge of the weight of the different films and their corresponding activities one can obtain a curve which by extrapolation, gives a measure of the activity of a film in whose case the adsorption of the β -rays by the material of the film itself is vanishingly small. We can, from this, determine the amount of U_x present in U_3O_8 or in UO_2 (NO_3)₂ from which the oxide was prepared.

To prepare the films I followed a method slightly modified from that of McCoy (Phil. Mag. 11, p. 176, 1906). His method consists in powdering U_3O_8 very finely along with chloroform, next mixing the powdered oxide with about 15 c.c. of chloroform and then pouring the mixture on to a disc. The chloroform on evaporating away leaves behind a film. I experienced

that uranium oxide, however finely powdered it may be, does not remain suspended in chloroform for a sufficiently long time to give a thin film of uniform thickness. It was further observed that the powder flocked together and settled more quickly when it was not sufficiently dried. Accordingly I employed the following method which worked very well.

The film was obtained on a brass disc which could be screwed on to the flange of a brass cylinder, open at both ends provided with flanges. The second open end could be shut in the same way by another disc. For washers in between the flanges and the discs I employed thin cork rings.

On shaking quickly a mixture of the oxide and chloroform put inside the cylinder and allowing the oxide to settle down, and next on removing the upper disc and allowing the chloroform to evaporate away, I got the film of the desired uniformity.

The weight and the corresponding activity of the films will be found in the following table. It also contains the calculated activity per milligram of U_3O_8 corresponding to the film and the inverse value of it, besides containing the magnitude of the thickness of the films.

In the case of very thin films the calculated value for the activity per milligram and also its inverse value should be constant, since the absorption of the β -rays by the material of the film may there be considered to be negligible. Plotting the inverse value of the activity per milligram of U_3O_8 against the corresponding weight of the film and next extrapolating, we get the limiting value of the above inverse one. From this the limiting activity per milligram of U_3O_8 can be obtained.

Weight of the films in grams	Activity of the film	Activity per milligram of U_3O_8 calculated	Inverse value of that in the preceding column	Thickness of films (approx. value)
5.7373	607 units	0.1060 units	99.4×10^{-1}	0.17 mm.
2.9539	392 units	0.1330 units	76.7×10^{-1}	0.09 mm.
1.3033	222 units	0.1703 units	58.7×10^{-1}	0.04 mm.
0.7103	128 units	0.1802 units	55.9×10^{-1}	0.02 mm.
0.3576	67 units	0.1881 units	53.2×10^{-1}	0.01 mm.

The thickness of the film has been calculated from its weight and area, and the specific of U_3O_8 .

All the above films were of the same diameter, viz., 7.57 cms. and therefore, were of the same area. The specific gravity of U_3O_8 is 7.31 (Landolt-Bornstien; Physikalisch-Chemischen Tabellen, 1905). We may see that the adsorption of the β -rays by the material of the film is quite great to justify our method of procedure.

The extrapolated limiting value of those in column four is 53×10^{-1} . Hence the activity per milligram of U_3O_8 , in the cases where the said adsorption is considerably small, is 0.1886 units. And the total activity of one gram of U_3O_8 when it is spread out as such thin films, is 188.6 units. We estimated that 1.7900 gram of the afore-said Uranyl nitrate was equivalent to one gram of U_3O_8 .

Therefore the total activity contained in one gram of our uranyl nitrate is 503.3 units.

Having thus obtained a measure of the total β -ray-activity of the uranyl nitrate, I started the investigation of the extraction of the uranium X. I shall, however, commence here forthwith to describe the method which gave a good result from the point of view of the yield of U_x and also form that of the convenience as regards its repeated extraction from a same sample of uranyl nitrate.

The method consists in dissolving a certain amount of uranyl nitrate in a definite volume of a saturated solution of sodium fluoride and in letting the mixture stand for several hours, and then in adding to it a small amount of the "colloidal" "sol" of ferric hydroxide. The said "sol" coagulates and settles down in a few hours carrying with it U_x . The precipitate can easily be freed from the uranyl salt by filtration and washing. It may be stated here that the above colloidal "sol" was prepared by adding a solution of ferric chloride, drop by drop, to a large volume of vigorously boiling distilled water.

To understand the role of the colloidal "sol" and also to find out the best condition for extraction, several experiments were carried out. They were all started with five grams of uranyl nitrate from the very same sample as was employed for the preparation of U_3O_8 used in making the films. The activity calculated from the said five grams was 527 units. For the measurement of the activity of U_x entrained by the precipitated colloid, that is to say ferric hydroxide, the latter was filtered and washed. The filter paper was then spread out on a thin aluminum foil and fixed thereon with wax after it was dried. A correction for the activity actually found was however necessary in this case. The brass disc carrying the film of U_3O_8 being thicker than the aluminum foil, the source of activity in the former case was nearer to the electroscope than that in the latter case when placed on the platform of the above. The nearer a source of activity is to the electroscope, the greater is the measure of its activity.

TABLE I

Amount of "sol"	equivalent to 2 mg. $FeCl_3$	equivalent to 5 mg. $FeCl_3$	equivalent to 10 mg. $FeCl_3$	equivalent to 15 mg. $FeCl_3$	equivalent to 20 mg. $FeCl_3$
Corrected activity	300 units	370 units	342 units	368 units	320 units
Percentage yield of U_x	57%	70.3%	65%	69.9%	60.6%

It will be seen from the following determinations that the amount of the ferric hydroxide "sol" does not influence the yield of U_x . In them the total volume of the liquid was in each case kept at 150 c.c., the said "sol" being mixed with uranyl nitrate before the addition of the solution of the sodium fluoride amounting to 1.5 g. of the fluoride.

The filter paper used for the above estimation not being of the desired quality, there was always a little loss of the precipitate. The amount of it passing through the filter paper was appreciably large in cases 1 and 5 compared with that in the other ones. This may account for the lack of uniformity in the yield in different cases. But on the whole the statement made above may be considered to hold good.

The following results as recorded in Table II will show that the yield of U_x increases at first and then attains a maximum value as the amount of sodium fluoride is increased.

TABLE II

	1	2	3	4
Amount of Sodium fluoride in grams	0.3	0.75	1.5	2.25
Activity of Ferric hydroxide in units	33.8	161	209	207
Yield of U_x	6.4%	30.6 %	39.6%	39.3 %

The above experiments excepting No. 1 were carried out under identical conditions. In each case the total volume of the liquid was kept at 150 c.c., and the amount of ferric hydroxide sol corresponded to approximately 10 mg. of ferric chloride. In the case of experiment No. 1, as the sol did not coagulate in the usual way, a few drops of potassium sulphate solution was added to coagulate it.

It was next found that the concentration of the substances employed had an effect on the yield of U_x . This is shown in Table III.

TABLE III

	1	2	3
The total volume of liquid.....	75 c.c.	150 c.c.	225 c.c.
Activity of the hydroxide (in units)	432	380	367
The percentage yield of U_x	82.2	72	69.7

For the above experiments sodium fluoride amounting to 1.5 grams and ferric hydroxide sol corresponding to 5 mg. of ferric chloride were used in each case.

On comparing the yields as given in Tables I, II and III, it will be seen that they are of different order. It was observed that when the ferric hydroxide sol was mixed with uranyl nitrate before the addition of sodium fluoride, the yield was greater than when sodium fluoride was added before the sol. And the function of ferric hydroxide having appeared to be that of absorption, it was suggested that if the hydroxide be made to remain in suspension in the medium for a longer period the yield would increase and thus indicate the cause of the anomalous results. The experiments made in this connection, however, did not show any increment in the yield. The amount of sodium fluoride taken for them, in each case, was 1, 5 gm. and that of the ferric hydroxide sol corresponded to 5 mg. of ferric chloride, the total volume of the liquid being 75 c.cs.. The mixture was kept stirred for a few hours by a mechanical contrivance while another similar mixture, for the purpose of control, was left unstirred for the same period.

	Stirred	Not stirred
Activity of hydroxide in units.....	475	475
The percentage yield of U_x	90	90

The yield of U_x was later on always found to be large when the reactants were allowed to remain in contact with one another for a long period of time.

The convenience of the method described above, with regard to the repeated extraction of U_x from a particular sample of uranyl nitrate, will be easily realized. The process involved in it being a colloidal one, it is not necessary to get back the uranium salt in a pure condition before a second extraction from it is attempted. In any other method where the carrier of U_x is obtained by the chemical interaction of two reactants, the above advantage does not exist. It is necessary for such extraction that the cation of the carrier be mixed intimately with uranyl salt before it is precipitated, but if there already existed in the medium a reactant which precipitates the above cation, no profitable extraction can be expected.

Before I proceed to describe the experiments that I undertook to elucidate the phenomenon involved in the process described above, I may state here the results of the yield which I obtained by following the methods already tried by others. In the cases of these determinations I took as before 5 g. of uranyl nitrate for each estimation.

Method employed	Entrainer used	Quantity of entrainer	Activity of entrainer in units	Percentage yield of U_x
1	Ferric hydroxide	Corresponding to i. 414 10 mg. $FeCl_3$ (Approx.)	ii. 67	481
2	Barium Sulphate	Corresponding to 21 mg. $BaCl_2$ (Approx.)	10 mg. $FeCl_3$	257
3	Lamp Black	0.2 g.	112	21
4	Cerium Fluoride	Corresponding to 17 mg. Cerous nitrate.....	495	94
5	Calcium Fluoride	Corresponding to 11 mg. $CaCl_2$ (Approx.) 10 mg. $FeCl_3$	351	67

In following method 1, the separation of U_x was effected twice from the same sample of uranyl nitrate, using each time 10 mg. of $FeCl_3$. This was done by precipitating uranium completely with ammonia and then dissolving the precipitated uranium with ammonium carbonate (Crookes, Proc. Roy. Soc. 1900, A, 66, 409). Method 2, was employed by Becquerel (C. R. 131 p. 137, 1900). Barium was precipitated in neutral solution with sodium sulphate. It may be stated in this connection that for a mixture of 5 g. uranyl nitrate and 21 mg. barium chloride, the barium was not found to be wholly precipitated until about 50 times its equivalent amount of sodium sulphate had been added. Method 3 was followed according to the directions given by Levin (Phys. Zeitsch. 1906, p. 692). The lampblack used was freed from fatty matter by chloroform and ether, while following method 4. (Krisch; Akad. Wiss. Wien. Ber. 129, 2 aa. pp. 309-334, 1920). It observed that in presence of uranyl nitrate (5 g.) about 1 gram of sodium fluoride was necessary for the precipitation of cerium fluoride. Method 5, has been tried by Madame Curie. It was observed that for a complete precipitation of calcium, from a mixture of 11 mg. of calcium chloride and 5 g. of uranyl nitrate, about 500 times its equivalent amount of sodium fluoride was necessary.

I may now describe the experiments mentioned before. With a view to see whether the phenomenon underlying the extraction by ferric hydroxide was only

that of absorption, we took equivalent quantities of sodium chloride, sodium nitrate, sodium sulphate, and sodium acetate, and mixed them separately with mixtures of the ferric hydroxide sol and uranyl nitrate. The amount of uranyl nitrate taken for each mixture was 5 g. and that of the sol corresponded to 10 mg. of ferric chloride. The total volume of the liquid in each case excepting that of sodium acetate was kept at 100 c.c.. In the case of sodium acetate the total volume of the liquid was kept at 200 c.c., because in a more concentrated solution uranium was found to be precipitated. In the case of the mixture containing sodium chloride and also of that containing sodium nitrate, ferric hydroxide had to be precipitated by the addition of 1 c.c. of the normal solution of sodium sulphate. The yield of U_x obtained in different cases is recorded in the following table.

Electrolyte	Amount of the electrolyte	Activity of the hydroxide in units	Percentage yield of U_x
Sodium chloride	50 c.c. of the normal sol.	79	15
Sodium nitrate	50 c.c. of the normal sol.	87.8	16.6
Sodium sulphate	50 c.c. of the normal sol.	45.3	8.6
Sodium acetate	50 c.c. of the normal sol.	230	43.7

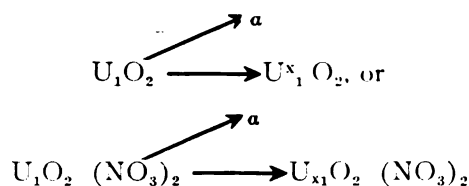
The different values of yield indicate that the phenomenon of adsorption is not solely concerned in the process of extraction by sodium fluoride and the ferric hydroxide sol. As regards other phenomena besides that of adsorption we may put forward three suggestions.

We have observed before that a large amount of a precipitant is required to precipitate completely barium sulphate or calcium fluoride in the presence of uranyl nitrate. The possibility of the inhibiting action of uranyl-ion has also been mentioned by Guy and Russel (J. Chem. Sec. 123, p. 2620, 1923). It may be that the uranyl-ion hinders as well the process of adsorption of U_x by ferric hydroxide. Consequently, a greater yield will result only when the said hindering influence is removed or suppressed. There remains the possibility of the formation of a complex negative radical containing uranium in the case of the mixture of uranyl nitrate with sodium fluoride or sodium acetate. Double salts such as uranyl sodium fluoride or uranyl sodium acetate are known. If uranium forms a complex negative radical, the uranyl-ion is necessarily absent or its amount diminished.

The second suggestion is as follows: The uranium X_1 is an isotope of thorium of which the fluoride and the acetate are insoluble in water. Therefore, the fluoride and the acetate or uranium X_1 being insoluble in water, it may be expected that they would be more easily carried down by ferric hydroxide.

The third suggestion may not appear to be a very convincing one. The observation of Freundlich and Wreschner (Z. Phys. Chem. 1923, 106, 366-377) however, lends some support to it. They have observed that when thorium nitrate is freed from its colloidal particles, it does interfere with the adsorption of Uranium X_1 by charcoal. Since uranium X_1 is an isotope of thorium, it seems difficult to explain the above observation. It may be that the anomalous behavior arises out of the form in which uranium X_1 is present along with uranyl nitrate. We shall try to explain it more clearly. Uranium 1 in decaying gives rise to uranium X_1 , but when uranium 1 is present in the form of uranyl nitrate, that is to say, U_2O_5 ,

(uranyl-radical) it may be that after the transformation of uranium I to uranium X_1 , the type of the radical remains unchanged. Thus the transformation may be considered to proceed according to the following scheme:



As an element occurring in two different forms behaves differently, $U_{x_1}O_2$ —(radical) may behave differently from U_{x_1} —radical, or its isotope Th-radical.

In connection with the extraction by sodium fluoride and ferric hydroxide sol, we have stated that if the reactants are allowed to remain in contact with one another for several hours the yield of uranium X is observed to be large. The above period of time may be the one required for the breaking up of the unstable peroxy-salt of U_{x_1} into its stable insoluble fluoride.

We have tried a few experiments to see if the said peroxy-salt really exists. But we do not find any indication of its existence from them. We may however describe these experiments because they may serve as methods for the determination of uranium X.

A definite amount of uranyl nitrate was converted into uranyl chloride by successive evaporation with hydrochloric acid. The chloride was then treated with a few milligrams of ammonium iodide and hydrochloric acid (Wyruboff and Verneuil, C. R. 126, 340, 127, 412, 1898) in order to reduce the supposed peroxy-salt. After evaporating away the excess of hydriodic acid by successive treatment with hydrochloric acid, the reduced uranium salt was oxydized to uranyl salt by a few drops of nitric acid. The excess of the acid was then evaporated away and the sample was then estimated for uranium X. As entrainers for uranium X we have used in this case cerium oxalate and also zirconium iodate.

Cerium oxalate being crystalline, there remains in this method little chance of uranium X being absorbed by it. We have, however, found that the amount of uranium X extracted depends upon the quantity of cerium salt employed. The procedure was that uranyl salt was mixed with a few milligrams of cerous nitrate and then treated with excess of oxalic acid. If excess of oxalic acid be not used, uranium oxalate is found to be precipitated. To precipitate cerium it is sometimes necessary to inoculate the solution with a few crystals of cerous oxalate. For each of the following experiments tabulated below we employed 5 g. of uranyl nitrate and 10 g. of oxalic acid.

Uranyl nitrate treated with NH_4I and HCl			Uranyl nitrate not treated with NH_4I and HCl		
Amount of cerous nitrate	Activity of cerous oxalate in units	Percentage yield of U_x	Amount of cerous nitrate	Activity of cerous oxalate	Percentage yield of U_x
29 mg.	185	35.1	31 mg.	192	36.4
59 mg.	322	61			
84 mg.	410	77.8	109 mg.	423	80.1

For experiments carried out with zirconium iodate as entrainer, the quantities of the various reactants employed were as follows: Zirconium nitrate 34 mg.

dissolved in 100 c.c. of dilute nitric acid (1 part of concentrated acid to 4 parts of water); sodium iodate, 2.5 g. dissolved in 100 c.c. of the above dilute acid; uranyl nitrate, 5 g.

Uranyl nitrate	Activity of zirconium iodate in units	Percentage yield of U_x
(i) Treated with NH_4I and HCl as described above.....	458	87
(ii) Not treated with NH_4I and HCl	461	87.5

The Author wishes to thank Madame Curie and her staff for the facilities extended to him for carrying out the above piece of work in her laboratory.

Note—Supposing the possibility of a radio-active compound undergoing a transformation according to the stated third suggestion, that is to say, without any chemical change, there remains the feasibility of separating some of the isotopes belonging to the Uranium series from those belonging to the thorium series, provided the type of the uranium oxide transformed is different from that of thorium oxide occurring along with the former in a mineral.

Let us take the case of ionium and its isotopes, thorium and radio-thorium. If the ionium had been formed from uranium occurring as UO_3 , the type of the ionium oxide according to the suggestion ought to be I_0O_3 . But the oxide of thorium occurring in a mineral is of the type ThO_2 . And if its desintegration products preserve the same type, there remains the possibility of these two different types of oxides of the isotopes behaving differently with certain chemical reagents.—Journal of Science, Vizianagaram, S. India.

Obituary

Carter Miller, Advertising Manager of The Timken Roller Bearing Company, died January 11, 1926, after a brief illness of a few days with pleura-pneumonia.

Mr. Miller came with The Timken Company six years ago and was promoted rapidly to various positions both in the field with The Timken Roller Bearing Service & Sales Company, and at the home office with The Timken Roller Bearing Company. Later he was given charge of the Advertising Department, which position he held until the time of his death.

Mr. Miller was born in Bay City, Mich., and attended the elementary schools in that city. He later attended Kenyon College at Gambier, Ohio, graduating with the class of 1919. While at this institution he was active in the social and athletic life of the school. He was a member of the Phi Upsilon fraternity. While at college he was a candidate to receive a Rhodes scholarship, which carries with it a course of study abroad. He, however, declined to take the examination and elected to enter the business world. Later at Canton, Ohio, he was an active member of Brookside Country Club and a charter member of the University Club.

In the business world, Mr. Miller was recognized as a keen analyst of advertising and business problems. His association with The Timken Company brought him in contact with leading automotive and industrial companies, who frequently sought his advice and council in matters of advertising and publicity problems.

SHEET AND TIN PLATE

Annealing Iron and Steel Electrically*

The Author of This Paper Covers Briefly the Aging, Normalizing and Annealing of Iron and Steel—Several Typical Electric Furnace Installations Discussed

By HAROLD FULWIDER†

THE ferrous metals — iron, steel and alloys of the latter — like most other metals, develop a degree of hardness when rolled, drawn, forged or cast. In addition to this quality, castings contain strains caused by uneven cooling in the mould and it is to relieve these strains and to impart softness to the metal that iron and steel are annealed.

The annealing of iron and steel is accomplished by heating the metal to a temperature of from 1400 deg. F. to as high as 1900 deg. F., depending on the alloy, after which the material is slowly cooled down to normal temperature.

The following table gives the approximate annealing temperatures for iron, carbon steel and some of the more common alloy steels:

Metal	Temperature, Deg. F.
Iron castings	1200 to 1400
Iron castings, aging.....	1000
Carbon steel castings.....	1500 to 1650
Carbon steel castings, normalizing.....	1600 to 1700
Manganese steel castings.....	1750 to 1900
Carbon steel forgings.....	1500 to 1650
Carbon steel cold rolled sheet, strip, wire	1300 to 1650
Silicon steel sheet.....	1500

Aging iron castings and normalizing steel castings have been included in the foregoing table because of the similarity of the process and the purpose of the latter. It has been mentioned above that iron castings contain strains due to the fact that the metal has not cooled at a uniform rate throughout when the castings were made. If no artificial method were employed, time would, to a large extent, take care of the matter, as the tendency is for the strains to equalize and create a condition of equilibrium. But, if this method is depended on to correct conditions, the castings must be stored for a long period before machining; if machined first and allowed to age afterward, it would subsequently be found that, as the strains were relieved, a certain amount of warpage or distortion had occurred during the process. This distortion could readily make the casting useless and, if the latter were already in service, serious damage might result to the machine or structure of which the casting formed a part.

This aging or relieving of strains can be accomplished in, relatively, a very short time by heating the casting to a temperature of about 1000 deg. F. and then cooling down slowly to normal temperature. Re-

garding the actual softening effect of this treatment, the metal is only partly annealed.

Normalizing.

Normalizing is the term applied to a process, the purpose of which is refinement of grain structure in steel castings, previous to heat treatment. The metal is heated to a temperature of 1600 to 1700 deg. F., which is well above the critical, and then cooled rapidly by quenching in air. This treatment refines the structure of the metal and alters the state of certain ingredients so that, with the subsequent quenching or hardening and drawing, maximum uniformity of strength and temper is secured.

Annealing.

Iron and steel castings, when taken from the mould, due to the state of the carbon content, are more or less hard. If they are to be used in rough form, no

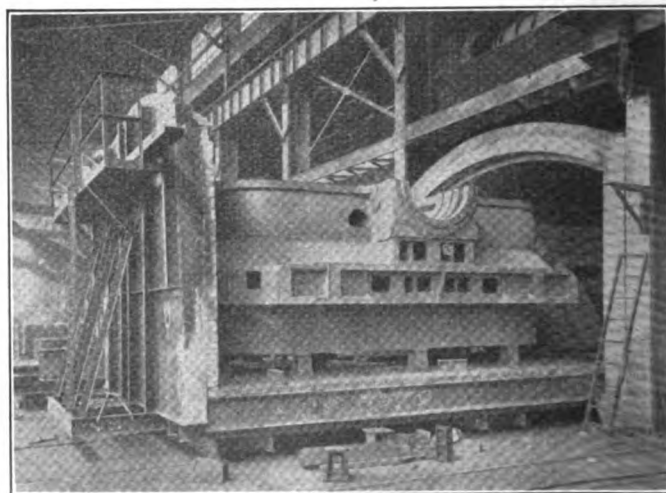


FIG. 1—Electric heat treating furnace equipped with automatic temperature control. Dimensions of heating chamber 15 ft. 10 in. wide, 27 ft. 7 in. long and 8 ft. 7 in. high. Maximum operating temperature 1000 deg. F., 620 kw., 550 volt, 3 phase.

treatment is required on this account, although the steel castings may be strengthened by heat treating, in which event they are first normalized as described above. All castings which are to be machined, however, must first be annealed or softened to improve their machinability. This requires heating to temperatures ranging from 1400 deg. F., for iron, to as high as 1900 deg. F., for manganese steel, after which the metal is slowly cooled to normal temperature.

*Report prepared for the N. E. L. A.

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When steel is made into forgings, cold rolled into sheets and strips or drawn into wire, the working of the metal imparts a certain amount of hardness which must be removed by annealing before subjecting the material to subsequent operations. Thus forgings must be softened for machining and sheets must be put in suitable condition for drawing and forming operations. Wire is annealed after each draw to reduce wear of dies and increase ductility of the metal. There is then a final anneal or heat treatment to make the wire suitable for commercial use. The temperatures required vary from about 1300 deg. F., for sheets and wire, to 1500 deg. F., for forgings. This latter temperature is also necessary for some of the alloy steels, such as silicon sheets used in the manufacture of motors, transformers, and other electrical apparatus.

Heating Mediums.

Until about four years ago, all commercial annealing was carried on in fuel-fired furnaces using coal, coke, oil or gas, and these methods are still in quite general use. In the past few years, however, there has developed in the metal work industries a recognition of the great importance of more accurate and uniform heat treatment of metals, including annealing, aging and normalizing.

The tendency is now, where maximum quality and uniformity of product are desired, to give consideration to the electric furnace for these operations. The actual cost of the electric energy used will, in most

annealing temperature. This means that the metal is heated through to just the right degree and will have the uniform grain structure which characterizes a perfect anneal. There are no hard spots to slow down machining operations and castings are less likely to break under strain and, as there is no overheating nor

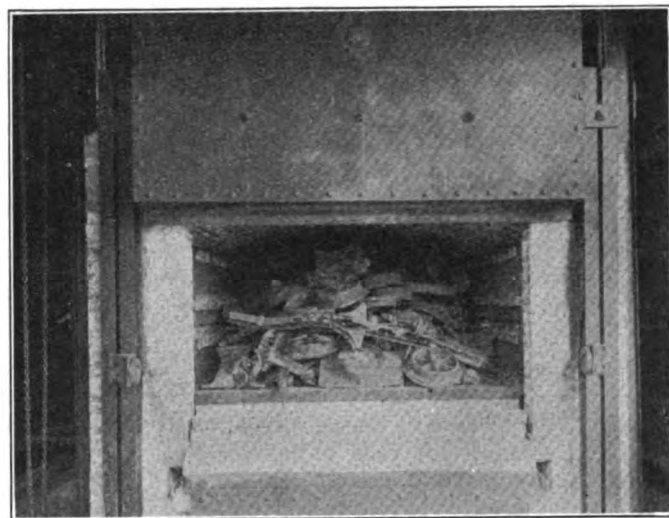


FIG. 3—Car bottom direct heat furnace for annealing steel castings. 1600 deg. F. Weight of charge 8 tons. Inside dimensions $6\frac{1}{2}$ ft. wide, 9 ft. deep, 3 ft. high. Connected load 200 kw.

flow of air through the furnace, scaling will be reduced to a minimum.

Temperature Control.

The furnace temperature is controlled automatically and is maintained more closely and accurately than is possible with the average fuel-heated furnace, and this is accomplished with a minimum of attendant labor. Usually the annealing process may be carried out over night, thus permitting the use of off peak power purchased at minimum cost. Night operation does not necessarily require night labor or attendance because the furnace may be charged late in the day, after which the power is turned on in the evening by a time switch which subsequently cuts off the furnace at the end of a pre-determined time period. The charge is removed in the morning when the men have returned to work. Often the same furnace is used during the day for other heat-treating operations.

Where the work to be annealed must be kept free from scale, as is the case with punchings, it is necessary to pack the steel in annealing boxes before loading into the fuel-fired furnace. These boxes are closed with a cover to exclude the air and, if made of iron, they are of heavy construction to resist the oxidation which results from repeated use. Boxes made of heat-resisting alloys have a longer life but cost much more. In either case, fuel is consumed in heating the boxes and (when it is realized that, not infrequently, the weight of boxes equals that of their contents, it is obvious to what extent these containers reduce the capacity of the furnace and increase the amount of fuel required for annealing.

Characteristics of Electric Heating.

The characteristics of the electric furnace permit a construction and method of loading which result in the furnace itself serving as the annealing box or con-

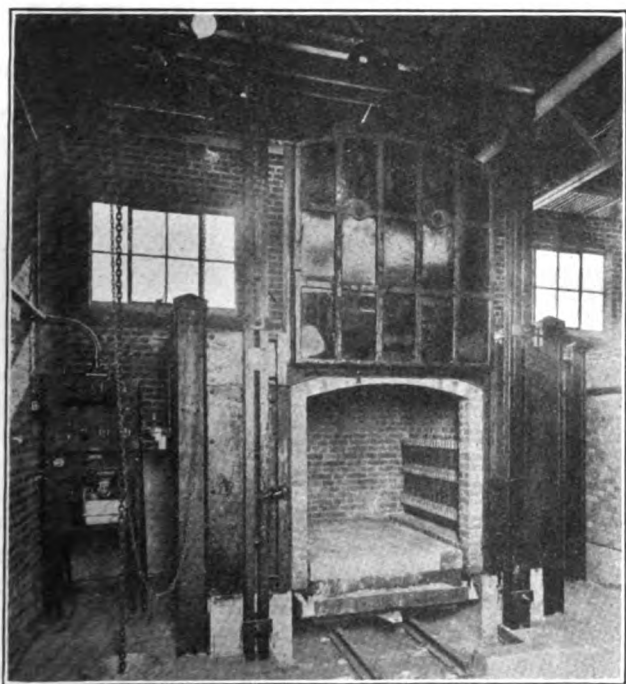


FIG. 2—Car type annealing furnace. Inside dimensions 5 ft. wide, 6 ft. 10 in. long by 4 ft. high. Connected load 120 kw. Operating temperature 1600 deg. F.

instances, be higher than the bare cost of fuel would be, but this is frequently justified by the results to be secured. In general, the electric furnace gives a better and more uniform product with less loss from scale, and quite often savings are realized which result in a lower over-all cost of product.

A properly designed electric furnace operates with a very uniform distribution of heat and at no time is the temperature of the heat source much above the

tainer. Thus, the electric furnace eliminates the items of expense for containers, saves the cost of energy for heating the latter and gives greater productive capacity with less floor space.

There are other advantages for the electric furnace which are important, if somewhat intangible. Improvement of shop conditions is now generally recognized as beneficial to both employer and employee. The latter is appreciative and does better work and more of it, if the surrounding temperature permits him to work in comfort and the air he breathes is free from injurious gases and dirt. If conditions are pleasant, labor turnover, one of the most serious items of expense today, is reduced to a minimum or virtually eliminated. Probably the electric furnace does more to bring about good shop conditions than any other modern appliance, and this should always be given due consideration in determining the type of furnace to be adopted for heat treating work.

Summarizing, the electric furnace for annealing gives uniform high quality of product, minimizes labor of attendance, reduces losses, gives greater productive capacity without increase of labor, saves the cost of annealing boxes and energy for heating same, and contributes greatly to the reduction and elimination of labor turnover. And it should be noted that the trade is beginning to demand electrically annealed iron and steel products.

The following is a brief description of a few typical installations where the electric furnace has been adopted on account of the advantages just enumerated:

Aging Large Castings.

A manufacturing plant, confronted with the problem of aging large iron castings weighing upward of 50 tons and of considerable variation in section, found that, with a fuel-heated furnace of the size required for such work, it was impossible to maintain a sufficiently uniform temperature throughout the furnace chamber. Accordingly, an electrically heated furnace (Fig. 1) of the car-bottom type was installed, equipped with ribbon units or windings located on the side walls and in the bottom of the car. The unit windings are so distributed as to compensate for door and end loss of heat, and uniformity of temperature is secured with less than one-third the variation encountered in the fuel furnace.

This furnace is 16 feet wide, 28 feet deep and 8½ feet high inside, and has a connected load of 620 kilowatt. The castings are heated to a temperature of 1000 deg. F. The aging cycle requires, in this case, about 48 hours; the power is on for from 12 to 14 hours heating the charge to temperature, after which the power is cut off and the castings are allowed to cool in the furnace for 36 hours when the charge is removed at a temperature possibly somewhat higher than 400 deg. F.

An electric foundry producing both steel and brass castings from electric melting furnaces is also using the electric furnace for annealing its product. The installation (Fig. 2), consists of two car-bottom furnaces, each 5 feet wide, 7 feet deep and 4 feet high, with a 120 kilowatt connected load. The steel castings are annealed at 1600 deg. F. These furnaces were installed over two years ago, after inspecting various furnaces in other plants, and have been in continuous operation ever since with but minor repairs on the cars, doors and sand seal.

Annealing Electrically.

Another steel foundry has been using a car-bottom, electric furnace (Fig. 3), for about two years, annealing miscellaneous steel castings. This furnace is 6½ feet wide, 9 feet deep and 3 feet high, with 200 kilowatt connected load. The average charge is about eight tons annealed at 1600 deg. F. The illustration shows this furnace with a typical charge of castings of various shapes and sizes ready to be annealed.

One large manufacturer is now using 14 electric furnaces, having a total connected load of about 2200 kilowatt for annealing silicon steel sheets and punchings. These furnaces are of the elevator type (Fig. 4) in which a car bottom is used for loading. This form of furnace is supported several feet above the shop floor on structural steel columns and the car with its

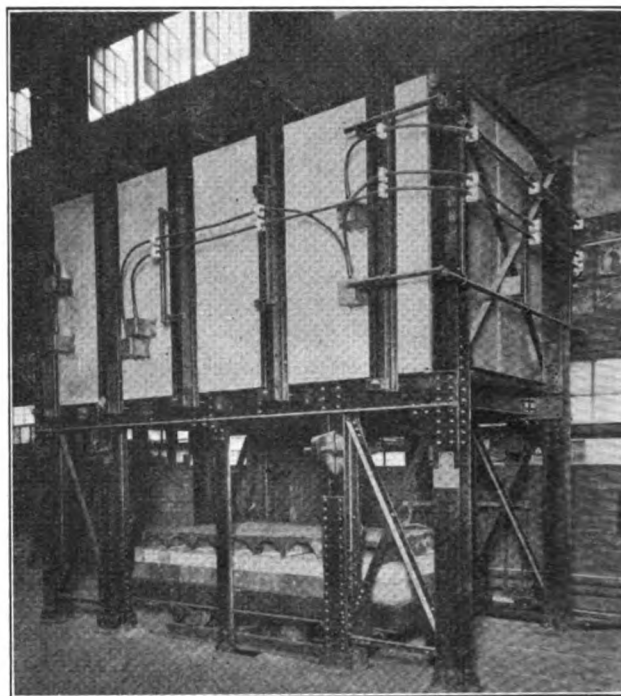


FIG. 4—Hydraulic elevator type electric furnace for annealing stator and rotor punchings. 200 kw., three phase, 500 volts.

charge is run under the furnace and then elevated by means of a hydraulic hoist. Thus the charge is brought into the heating chamber and the bottom opening of the latter is closed by the car top with a sand seal. This type of furnace is more effective in excluding the air than the ordinary car-bottom type with the sliding door at the end.

The use of heavy annealing boxes required formerly with the fuel furnaces has been entirely eliminated, the electric furnace itself serving as the container. There is saved the cost of annealing boxes as well as their maintenance and the cost of energy for heating such containers. The capacity of the furnace is greatly increased with a material saving in floor space, and working conditions in the shop are vastly improved. Everything considered, the cost of annealing has been reduced approximately 50 per cent.

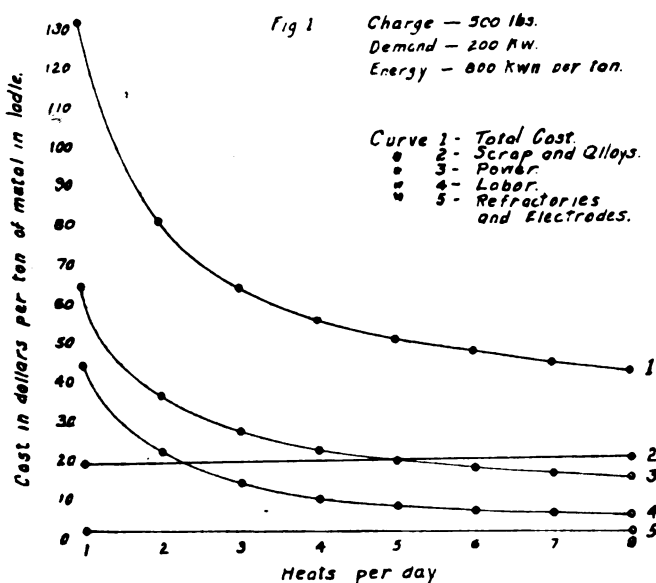
The work is now turned out free from scale and uniformly well annealed. One of the smallest of these furnaces is 7 feet long, 2 feet wide, and 1½ feet high, with 130 kilowatt connected load. Eleven heats of 3½ tons each are secured per week with an economy of about 11 kilowatt hours per 100 pounds.

Economic Operation of Electric Furnaces

Results of Tests and Records Made During the Operation of Five Standard Sizes of Well Known Melting Furnaces

By R. S. KERNS*

MUCH has been published in the last several years about electric furnace operation, the different methods employed in the successful melting of different irons and alloy steels as well as plain carbon steels, excessive overloads successfully taken care of by electric furnaces, etc., but little has been published concerning the economic operation of these latest additions to the iron and steel foundries.



Electric furnaces can be operated at a loss or profit to the foundry employing them as a melting medium. Much depends on such conditions as, capacity of furnace with regards to foundry size and output per month, ability to speed the furnace up to overloads to take care of business peaks, and intelligently proportioning the demand cost to the energy cost per ton of metal in the ladle, whether the electric furnace spells ruin or profit for the foundry owner.

It is true that the same conditions regarding scrap, labor, and power do not exist in all parts of the country, so the writer has tried to strike an average in these particular items. Some readers of this article will probably say, "Where does he get a melter for \$160 per month" another "Where does he get power at that rate", and still another may think the scrap price too high or too low. The writer has investigated such items in all parts of the country before writing this article and believes he has struck a fair average.

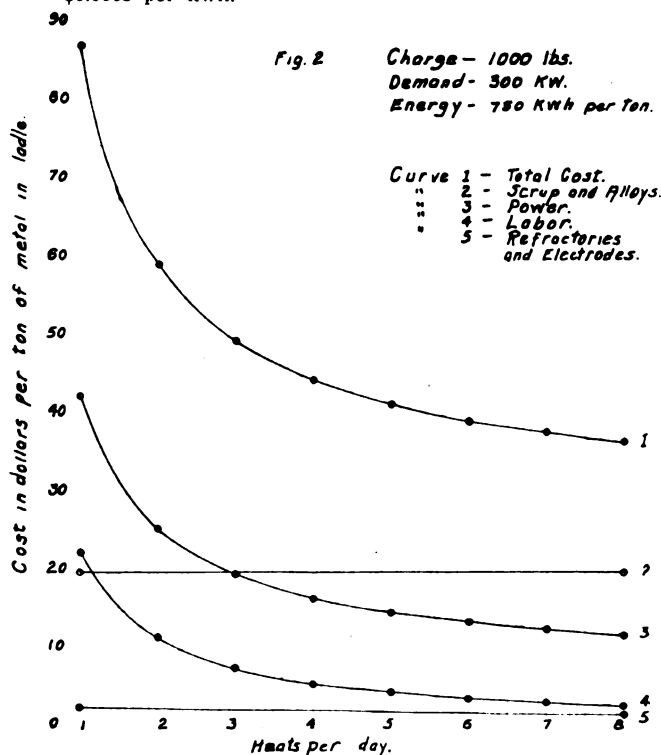
Five standard sizes of a well known make of three phase, automatic controlled electric furnace produced in the United States have been selected upon which to base the comparisons. Such figures as power consumption per ton of metal in the ladle and demand have been taken from an average of quite a number of each size of these furnaces under actual operating conditions. The only "fly in the ointment" being,

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that these figures apply to acid steel practice. The difference in acid steel figures and basic steel figures would come in an increase in energy consumed per ton of metal, a slight increase in refractory and electrode costs, and an increase in the labor cost due to the fact that under the same conditions the monthly tonnage of acid steel would be greater than basic steel.

As a basis for getting the power cost per ton of metal in the ladle, the writer has used a standard form of one of the largest power companies in the Central states, taking it as an average of most of the power company rates for using large blocks of so-called "unrefined power." Where the furnace company includes the power transformer with the regular furnace equipment, there is no additional charge by the power company for transformer equipment, so the final bill is for "demand charge, energy charge, and a coal clause", as follows

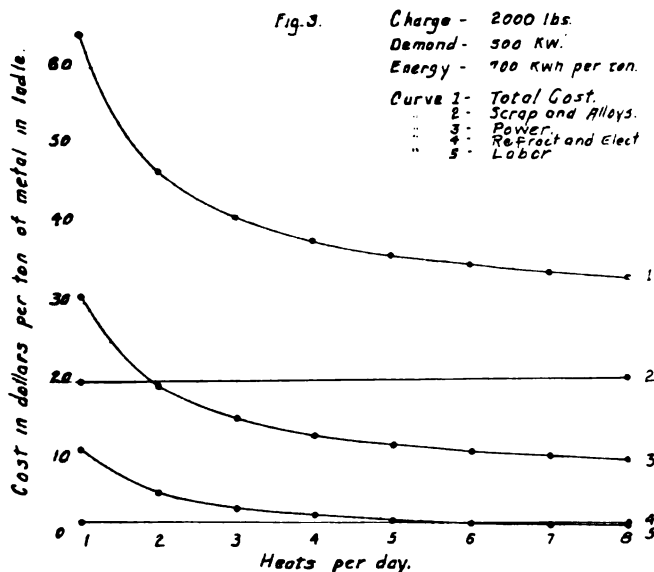
Demand charge, based on an 85 per cent power factor:	
First 150 kilowatts at.....	\$2.00 per kw.
Next 50 kilowatts at.....	1.00 per kw.
Balance kilowatts at.....	0.75 per kw.
Energy charge:	
First 25,000 kwh. at.....	\$0.011 per kwh.
Next 25,000 kwh. at.....	0.010 per kwh.
Next 50,000 kwh. at.....	0.009 per kwh.
Next 50,000 kwh. at.....	0.008 per kwh.
Balance kwh. at.....	0.0075 per kwh.
Coal clause:	
	\$0.0003 per kwh.



In some localities the electric furnace user can arrange for more favorable rates, while in other sections with which the writer is familiar, such rates as an energy charge of one cent per kwh. and no demand

charge or coal clause, and still another, where due to shop conditions, the furnace has earned a demand charge per month with no additional energy charge or coal clause. In these two cases or similar ones the curves accompanying this article would not hold true. As stated before the above rate was used as an average and not as an exceptional rate either high or low.

Scrap and alloy prices are based on the average market price, the scrap being listed as first class melting scrap. Some foundries use a better grade of scrap



which costs in the neighborhood of \$22 to \$23 per ton and save the difference in better operating conditions, as, less power consumption per ton of metal, longer refractory life, better results from electrodes, and a better quality of steel consistently. While again, the writer has had experience with one foundry in particular that bought cheap scrap which resulted in longer time for the heats with increased costs of electrodes, refractories, and power per ton of metal in the ladle.

Electrode costs in the following curves were taken from actual practice where graphite electrodes were used. However, with the latest developments in the carbon electrodes, it is the opinion of many electric furnace operators and owners that it will result in quite a saving on electrodes, this remains to be seen.

Refractory costs in the curves were taken from actual practice for a good grade of silica shapes. While some electric furnace operators are having excellent results with clay shapes for their roofs, the resulting refractory cost per ton of metal in the ladle being quite a bit below that of silica shapes.

In the labor costs, it will be noticed that a melter is rated at \$160 per month and a helper at \$120 per month, this may seem low for a melter but then if the helper is dispensed with on the smaller sizes it will allow a good salary to the one having charge of the furnace. In many places on furnaces up to the 3,000 lb. size the helper is taken from the foundry labor gang to help with the charging and any other work the melter may have for him to do. The helper cost is then absorbed by the foundry labor costs and not applied directly to the furnace costs. With the 3,000 lb. and 6,000 lb. sizes one helper should be on the furnace at all times and any additional help taken from

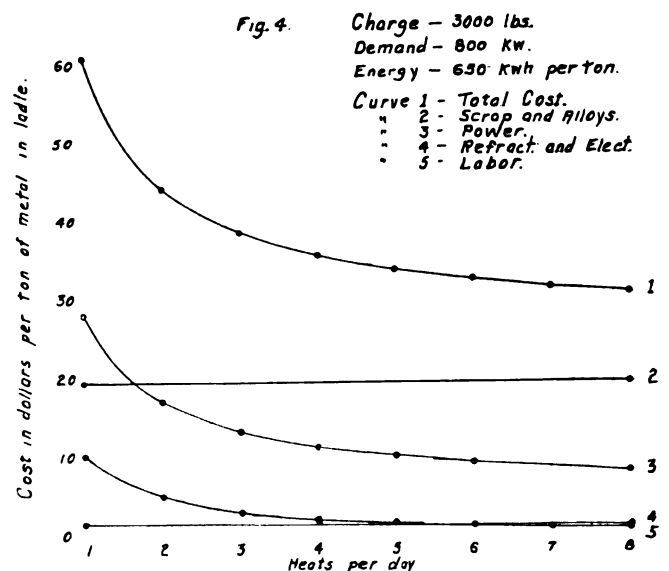
the regular foundry gang. This would dispense with one helper and the extra \$120 could be split with the melter and helper in whole or in part and the remainder could be applied to some other item or counted as a saving.

Discussion of the Curves.

Figs. 1 to 5 inclusive show how the costs on electric furnaces having nominal ratings of 500, 1,000, 2,000, 3,000 and 6,000 lbs. have been analyzed. It will be noticed that the two items Power and Labor are the deciding factors in the final cost of the metal in the ladle when the furnace is operated at a high or low load factor, i.e., operated at one heat or eight heats or more per day. These curves are all based on from one heat per day to eight heats per day and 25 days per month.

To the uninitiated in electric furnace operation and costs the following simple calculations will serve to show how the Power and Labor costs are obtained and why they influence the cost of metal in the ladle to such a degree. Taking for instance in Fig. 1, one 500-lb. heat per day and 25 days per month; this will mean 25×500 or 12,500 lbs. or 6.25 tons per month. With a melter at \$160 and a helper at \$120 the monthly furnace labor will be \$280, and dividing \$280 by 6.25 it gives a labor cost of \$44.80. In getting the power cost using the rates as given in the first part of this article and taking the average operating figures for this size furnace which are 800 kwh. at 200 kw. there will be:

Demand charge:		
First 150 kw. at \$2.00 or.....	\$300.00	
Next 50 kw. at 1.00 or.....	50.00	
	\$350.00	\$350.00
Energy charge:		
6.25 tons at 800 kwh. per ton or 5,000 kwh.		
First 5,000 kwh. at \$0.011 per kwh.		
or	\$ 55.00	55.00
Coal clause:		
5,000 kwh. at \$0.0003 or.....	\$ 1.50	1.50
Total power cost.....		\$406.00



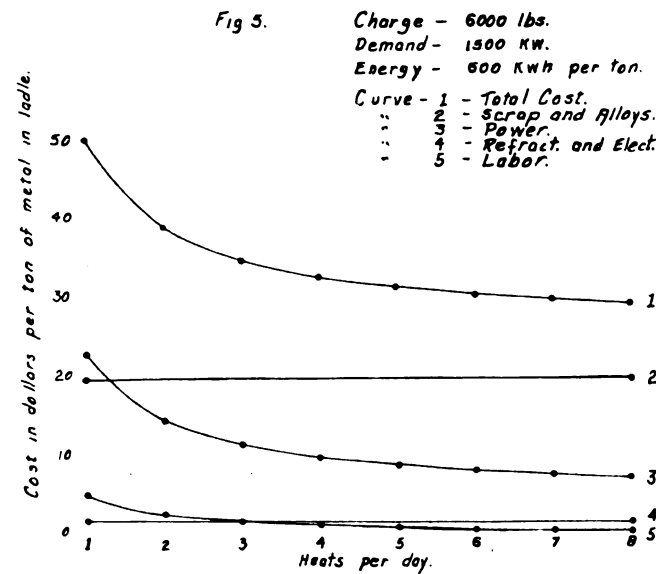
Cost per ton of metal in the ladle will then be \$406.50 divided by 6.25 or \$65.04.

Taking scrap and alloys at \$20 per ton and refractories and electrodes at \$2.50 per ton of metal in the ladle for one heat per day, and \$1.80 for eight heats

per day, the total cost for the metal in the ladle for one heat per day and 25 days per month will be:

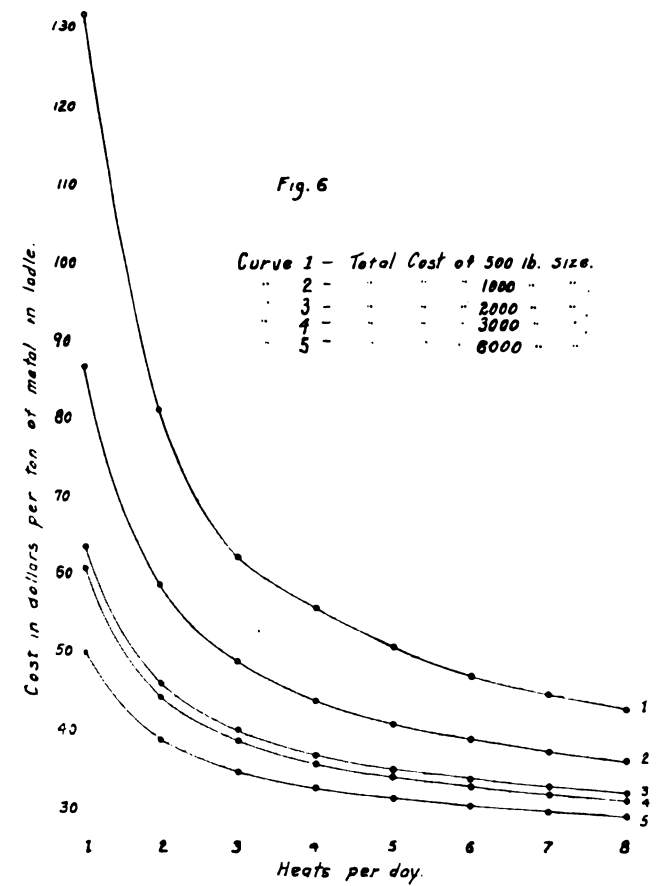
Power	\$ 65.04
Labor	44.80
Refractories and electrodes.....	2.50
Scrap and alloys.....	20.00

Total cost of metal per ton in the ladle..... \$132.34



Now going to the other end of the total cost curve and taking the cost for eight heats per day and 25 days per month the following costs are obtained in the same manner:

Monthly tonnage will be 43.75, and power consumption 40,000 kwh.:



Power	\$37.04
Labor	22.40
Refractories and electrodes.....	2.40
Scrap and alloys.....	20.00

Total cost of metal per ton in ladle..... \$81.84

It will be noticed the total cost curve in the larger sized furnaces are not so abrupt as in the smaller furnaces, this being due to the fact that the power cost and labor cost are distributed over a larger tonnage and also due to the sliding scale of the power rate.

Fig. 6 is a composite of the five total curves. Here it will be noticed there is not much difference in the operating costs between the 2,000 lb. size and the 3,000 lb. size. This is due to the increased labor cost assigned to the 3,000 lb. size, it being increased from \$280 per month to \$400 per month.

These curves will tend to show that it is more economical to operate a small furnace at a high load factor than it is to operate a larger furnace at a low load factor. Take for instance the cost of production for 6,000 lbs. with the 3,000 lb., the 2,000 lb. and the 1,000 lb. furnaces, i. e., three 2,000 lb. charges, two 3,000 lb. charges or six 1,000 lb. charges. With the 3,000 lb. size the total cost will be \$44.96 per ton of metal in the ladle, with the 2,000 lb. size it will be \$40.81 and with the 1,000 lb. size it will be \$39.37 per ton.

In conclusion the writer would say that before installing these most efficient melting mediums it is very important that the foundry owner considers very carefully the future outlook in his particular line of castings or the possibility of expansion and then install the smallest size electric furnace that will nicely take care of that tonnage and after the furnace is once started it should be operated at as high a load factor as possible.

A. S. M. E. Activities

Providence meeting plans under way.

Under the leadership of Chairman Luther D. Burlingame of the Executive Committee, a tentative program for the Regional Meeting of the A. S. M. E. to be held in Providence from May 3 through 6, has been whipped into shape. The outstanding feature will be the all-day trip to the Newport Torpedo Station on May 6 in which the entire party, both men and women, will participate. Other entertainment events will be a reception on Monday evening, a Rhode Island clam bake on Tuesday, and an informal dinner, dance and card party on Wednesday. There will be many excursions to points of industrial and scenic interest in and about Providence. Of the probable eight technical sessions there will be two on Machine Shop Practice and one each on Industrial Power, Wood Industries, Central Station Power, Textile, and Education and Training for the Industries.

Coming Meetings of A.S.M.E. Local Sections.

Atlanta, February 18—At Chamber of Commerce at 8:00 P. M. Subject: The Diesel Engine Today and Its Probable Future Development. Speaker: N. B. Henry, Works Manager, Murray Company, Atlanta, Ga.

Metropolitan, February 24—In Engineering Auditorium at 8:15 P. M. Subject: By-Product Processing of Coal. Speaker: H. W. Brooks.

THE SAFETY CRUSADE

Personal Factor in Accident Prevention

By W. H. CAMERON*

IF you would stop 90 per cent of all accidents, you must learn how to teach safety to the individual and keep up that teaching. The workers over whom you have supervision must be taught how to react physically, mentally and morally to the conditions or situations which cause accidents.

We know more about the causes of accidents today than we did 15 or 20 years ago. The employer now realizes that he is responsible for working conditions—for the construction and equipment of his factory. He provides the place to work. We have also learned that the word "carelessness" no longer covers all the mental causes of accidents. What is called carelessness is usually a symptom of some physical, mental or moral defect in the individual.

Others have discussed with you in these classes the problems of mechanical safeguarding and other purely engineering factors in accident prevention, but my talk must be confined to accident problems that rest largely if not entirely upon you. You who hold supervisory positions in industry have a great responsibility and a wonderful opportunity to be of service to humanity. You know your men personally—their abilities, their limitations and their weaknesses. Without this personal contact with men, great accomplishments in accident prevention are practically impossible.

First of all, we must understand the primary causes of accidents. There are many classifications of accidents, but fundamentally they are caused by either men or machines. About 90 per cent are due to physical, mental or moral defects of the persons involved. The remaining 30 per cent may be blamed on machines, although if we dig deep enough into accident causes we usually find the human element has slipped a cog in some place. Perhaps the men who built or installed the machine have neglected some seemingly unimportant detail. The really unavoidable accidents form a very small percentage of the total, and as engineering skill improves our processes and machines they will become still fewer.

But it is quite probable that we shall always have the personal factor with us. All men have natural mental and physical limitations, some are intelligent but forgetful, while some are naturally so dull that they have difficulty in learning the simplest facts. Any program of safety education must take all these types of men into consideration.

The problem of preventing accidents due to the personal factor may be summed up in two words—"safe practices." It is not enough to know how to work safely—it must become a habit. The gunner in the gun turret of a battleship has learned through long and monotonous drill to do the right thing unconsciously in emergency.

The same applies to many of our actions in everyday life. We acquire habits in childhood and the majority of our actions are performed unconsciously. Life would become burdensome if we had to stop and think before every action. The time will probably come when the operation of every machine and the method of performing every task will become standardized from the safety standpoint. The public conscience is opposed to the killing and maiming of workers, and in self protection employers will insist on safe methods of working.

The first step in the prevention of accidents due to the individual is to have him examined mentally and physically at the time of employment. Perhaps the time will come when there will be community medical stations through which every worker must pass before he can get a job in any local workshop. The doctor will certify as to the applicant's capacity for work in high places, whether his eyesight will permit close application to certain kinds of work, whether his heart and other organs are equal to the demands of strenuous occupations, whether he is suffering from hernia, and so on through the list of physical qualifications for the demands of modern industry.

The psychological as well as the medical expert will examine applicants. Judgment, caution, memory and intelligence will be noted. With such data available, the worker may be placed in occupations for which he is mentally and physically fitted. These examinations are not intended to deprive any man of an opportunity to earn a living, but it is neither fair to the man nor to his fellow workmen to place him on a job where he will be a menace to himself and to others.

When the right man is placed at the right job, he becomes subject to the safety program of the shop. A book of safety rules is a good basis for instruction in safe practices, but if safety education is limited to handing out rule books, it is a sure bet that the shop will never make any astonishing records in accident reduction. The new man may read the rules conscientiously or he may not. Perhaps he does not understand their application to his job.

It's the personal touch that wins in safety. Show the man you are sincerely interested in him and he will respond in the right way. Even his chronic grouch and the hard-boiled safety scuffer can be won over and converted into boosters with a little patience.

Develop the right attitude toward safety in your department and the men themselves will do the rest. It is difficult to compel men to work safely, but if the whole proposition can be sold to them on its own merits, you will find very little need for stern discipline. New men will find it advisable to get in line or find jobs elsewhere if they persist in unsafe practices.

*Managing Director, National Safety Council, Chicago.

The safety movement is essentially democratic. That is why safety committees have proved so valuable in cleaning up bad accident records in many plants. We sometimes hear the complaint that the safety committees waste a lot of time for the amount of work they accomplish. But if only one man is saved from a disabling injury in a year, I think you will agree with me that all the time spent in committee meetings during the year is well worth while. If accident prevention were a purely engineering problem, one engineer could probably accomplish as much as a committee. But that is only the beginning of a big problem which is essentially a human one. As I see it, the safety committee is a valuable feature because it keeps many men interested in keeping the plant safe.

In the course of a year you undoubtedly receive many safety suggestions from the men in your departments. Perhaps some of them are so far fetched that they seem absurd. But remember that the man who made it is entitled to consideration. He has shown that he is interested and a tactful explanation to one who has made an impracticable suggestion softens the rejection and keeps a friend for yourself and for safety work.

Remember also that a good safety record is impossible in an atmosphere of fear and mistrust. If men hate each other, the foreman and the management, accidents are almost sure to thrive. The men have little contact with the management and they know little of the economic problems of the front office. To them you are the company. You can do much to straighten out difficulties that may arise from time to time in even the most harmonious plants when the evil tongues of rumor and misinformation are trying to stir up trouble.

There are many aids which you can use in carrying out the safety program, and the most important of these is a loyal following. I have known plants where the management was not entirely sold on the safety organization and where industrial relations were not all that could be desired, but splendid records were made in certain departments entirely through the efforts of superintendents and foremen.

Perhaps in your department there is some man who has certain qualities of leadership and is a safety enthusiast. If there is, cultivate him. Give him a job on your safety program, show your appreciation of his efforts and you will develop a loyal and valuable assistant. As a worker he can get in closer touch with his fellow workers than anyone in authority can possibly do.

A safety program requires an infinite amount of patience. You can never feel sure that your department has been made safe and will remain so. Some men require constant teaching before they grasp simple facts and even the most intelligent may forget. It is very easy to get the idea that because you have told a man once he knows as much about it as you do. Don't be afraid to do your stuff more than once, but spring the same idea on them in a different way each time if you can.

It takes a variety of appeals to maintain interest in safety. In this you will find the bulletin board one of your greatest allies. A safety poster attracts attention and during the brief moment that a man looks at it while taking a drink or punching the time clock, its picture and message carry home the truth.

Do not be afraid that your production records will suffer if your department makes the effort necessary to prevent accidents. One serious accident may take more time from productive work than a dozen safety committee meetings. Companies that have made good safety records have testified that production actually increased as accidents decreased. This is not surprising when you consider that an accident is a sign of inefficiency on some one's part.

Numerous articles have been written on this subject of the personal factor in accident prevention and I do not feel that the subject has been exhausted. But I might sum up the whole subject in one sentence—"Know your men." Each presents a different problem. Learn their personal characteristics and habits, their good qualities and their weaknesses. Do not pry into their personal affairs, but if you know something of a man's home background it will help you to understand him better. There may be domestic difficulties or physical ailments at the bottom of his recklessness, indifference, forgetfulness or whatever the trouble may be.

Above all, gain the confidence of your men. Some may have to be driven, but the great majority of American workingmen will stick by a "square shooter" through thick and thin, in safety work or in any other worth while purpose.

A Long Felt Need in the Aluminum Industry at Last Here

The sheet aluminum rolling mill of the Sheet Aluminum Corporation of Jackson, Mich., has commenced operations producing a full line of aluminum sheets and has filled a long felt want in the aluminum industry. Rolling mill equipment and other machinery is all specially designed and is considered the finest of its kind in the aluminum rolling mill industry.

The Sheet Aluminum Corporation succeeds the Northern Manufacturing Company, which company was organized for plant construction purposes.

The general sales offices of the company are located in the Ford Building, Detroit, with Mr. W. J. Moore, vice-president in charge of sales. Mr. Moore also is president of the Allied Metal Products Corporation of Detroit, manufacturers of extruded aluminum moldings, bars, and shapes.

The officers and directors of the company are well known in the aluminum industry and financial circles.

The Lipe Speed Reducer

The same initiative which created around the automobile transmission one of the outstanding developments in the gear industry has been brought to bear upon the application of speed reducers to various forms of equipment.

The new booklet being distributed by the W. C. Lipe Company of Syracuse illustrates these many interesting applications. Electric hoists, ash hoists, with telescopic mast, swinging boom or platform, dumb-waiter hoists, geared conveyor pulleys, coil-winders, all are shown, together with details of flexible couplings and speed reducers.

Tables of over-all standard sizes and also prices of standard units are given.

The Complete Utilization of Coal and Motor Fuel*

By A. C. FIELDNER† and R. L. BROWN‡

M. R. Campbell¹ of the U. S. Geological Survey estimates the unmined coal of the United States existing within 3,000 ft. of the surface at 3,500,000,000,000 short tons. This amount of coal is enough to cover the entire State of Ohio (area 41,040 sq. miles) to a depth of about 76 ft. "Similarly, if all the coal that has been mined in the United States, plus about 40 per cent for waste, a total of 17,119,010,000 tons, were piled to a height of 76 ft., it would cover a square a little more than 14 miles on either side, in other words, the exhaustion up to the end of 1918 amounted to only about one-half of one per cent of the original total supply."

There seems no doubt but that most of this great mass of coal, constituting over 60 per cent of the world's reserve will still be in the ground when all the petroleum available by drilling and pumping methods becomes exhausted in the United States. For the United States, coal is the logical source of liquid fuel substitutes for petroleum gasoline.

It is recognized that shale oil and alcohol from vegetable matter will contribute considerable quantities of fuel, but they can not carry the bulk of the load if we are to continue using anything like the amount of gasoline consumed today.

The average oil shale yields little if any greater quantity of distillate per ton than may be obtained by the low temperature distillation of bituminous coal, and coal has the big economic advantage of being mined near the centers of population and in furnishing a residue that can be sold as a relatively high priced smokeless domestic fuel. Most of our shale is found in the sparsely populated western states and the residue is worthless.

The amount of alcohol that can be obtained from the fermentation industries is also limited. The diversion of any considerable acreage to growing vegetables or grain for motor fuel would cut too deeply into our food supply to be tolerated.

A Demand for Motor Fuel Substitutes Will Stimulate More Complete Utilization of Coal.

We must admit that the present day utilization of coal is far from complete. Much progress has been made in certain lines but the fires of the bee-hive coke-oven can yet be seen by the traveler between Pittsburgh and New York. The combustion of raw coal and the transmission of the heat to the boiler in our most modern central power stations have indeed almost reached perfection. Eighty-six to 90 per cent thermal efficiency is now being obtained in regular

operation in the best powdered coal fired plants. Much gain in this direction is not possible. However, the great manufactured gas industry and the coking industry are just beginning to see the future possibilities in processing coal to produce fuels of higher form-value and other by-products. The gradual failure of the yearly output of petroleum gasoline to meet the increasing needs of the automotive industries, with the consequent rise in prices of motor fuel should stimulate the carbonization of coal by both high and low temperature processes. The automobile may yet help to bring about, to no small degree, that desired millenium when the atmosphere of Pittsburgh will be as free from smoke as when George Washington first beheld the beautiful valley of the Monongahela River. This ultimate aim can be accomplished by processing all coal, except perhaps inferior grades, by carbonization processes yielding gaseous, liquid and smokeless solid fuel. Inferior grades may be burned directly in great super power stations, which produce very little smoke. Let us evaluate the present day practical and future theoretical possibilities for obtaining motor fuel from coal.

Processes for Obtaining Motor Fuel from Coal.

The processes for obtaining motor fuel from coal may be grouped in three classes:

1—The carbonization of coal, including the gas manufacturing and coking industry, and low temperature carbonization.

2—The hydrogenation of coal by the Bergius process.

3—The complete gasification of coal and conversion of the resulting gases by pressure synthesis into methanol, "synthol," and other liquid combustibles.

Of these processes only the high temperature carbonization process is in actual commercial use, if we except the distillation of brown coal in Germany which is done at low temperature.

A number of large scale low temperature experimental units still in a developmental stage are operating intermittently in both this country and abroad. The principal object in most of these experiments is the production of a convenient form of smokeless solid fuel. Any considerable increase in the price of liquid fuel would probably make some of these low temperature processes commercially successful.

The partial liquefaction of coal by hydrogen under pressure according to the Bergius method has been under laboratory investigation in a number of European laboratories, and one of us saw a 2-ton per day unit operated by Dr. Bergius at Rheinau near Mannheim, Germany, 12 months ago.

A recent Berlin report in the New York Commercial of September 9, states that "A credit of 2,500,000 marks (\$600,000) has been allotted jointly by the German government and the Prussian government to the Evag Company toward erecting a factory for pro-

*Published with the permission of the Director, U. S. Bureau of Mines.

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¹Campbell, M. R., The Coal Fields of the United States; Professional paper 100-A, U. S. Geological Survey, 1922, p. 25.

ducing oils from coal under the so-called Bergius process. This is being erected at the Wenceslaus mine in Lower Silesia. It will have a capacity for treating 200,000 tons of coal dust a year." If this report is true, we should have full information on the commercial possibilities of this process long before it is needed to augment our own gasoline supply.

The commercial production of methanol in Germany from carbon monoxide and hydrogen is an assured fact as witnessed by the methanol importations in the port of New York during the present year. Disturbing as this may be to our own wood distillation industry, it unquestionably puts an entirely new aspect on the ultimate gasoline substitute for motor fuel. Even though pure methanol is an untried motor fuel, the fact that it can now be synthesized on a large scale at a reasonable price opens up a new field of possibilities in which are included the synthesis of other combustible liquids such as Franz Fischer's "Synthol" from water gas,² on which he reported at the Baltimore meeting of the American Chemical Society last April.

The future economic significance of Bergius and the synthetic processes will become apparent as we discuss in more detail the yields and the possible total production by carbonizing coal wherein the motor fuel is a by-product. The total quantity of any by-product is necessarily determined by the market demand for the main product.

Motor Benzol from Coke and Gas Works.

In the modern by-product coke-oven a ton of coal yields from three to four gallons of crude light oil of which 60 to 70 per cent after proper refining may be utilized as motor fuel. During the year 1923, the latest year for which the data are complete and given by the U. S. Geological Survey,³ the total coal coked was 55,500,000 short tons of which two-thirds was made in by-product ovens. The light oil recovered was 135,000,000 gal. of which 95,000,000 would have been suitable for motor fuel. This figure is approximately $1\frac{1}{4}$ per cent of our gasoline requirement of 7,600,000,000 gal. for the year 1924. If all the coal carbonized in 1923 were put through by-product ovens, the yield would not exceed 2 per cent of these requirements, and finally if the entire 1923 output of 545,500,000 tons of bituminous coal were subjected to the by-product coking process, it would furnish only 1,335,000,000 gal., or about 18 per cent of the gasoline used in 1924. Obviously the ultimate production of benzol possible can only serve to furnish a limited amount of blending agent for gasoline-alcohol mixtures.

Ethyl Alcohol from Coal Gas.

In this connection, there is a possibility of virtually doubling the quantity of motor fuel from the carbonization of coal through the conversion of ethylene in coal gas into ethyl alcohol. Bury⁴ at the Skinninggrove Iron Works in England obtained an average yield of 1.6 gal. of alcohol per ton of coal carbonized in by-product ovens in a small experimental plant. Sulphuric acid was used as the absorbing medium

to form ethyl sulphuric acid which on hydrolysis yielded ethyl alcohol. Although the English experiments were not commercially successful, Vallete⁵ has recently reported that a similar process is to be installed in connection with a Claude plant for the manufacture of synthetic ammonia from by-product coke oven gas at the Bethune mines in France. The ethylene is to be separated through compression and refrigeration, from the other constituents of the coal gas. The cost is stated to compare favorably with that of distillery alcohol. Should this process eventually prove technically successful, it would afford a means of adding 65 per cent more to the motor fuel per ton of coal carbonized, which would be but 3.3 per cent of the 1924 gasoline consumption if all the coal carbonized during the year were so treated, or 30 per cent for all the coal mined. The most optimistic estimate of expansion in the use of gas and coke would put the total motor fuel to be had from this source nearer the 3.3 per cent figure than the 30 per cent.

Motor Fuel from the Low Temperature Distillation of Coal.

Let us now turn our attention from the prevailing method of the coke and gas industry to the field of low temperature carbonization which according to many writers affords a means of replacing our petroleum resources. It is an established fact that the low temperature distillation of coal yields from two to two and a half times as much tar per ton as high temperature carbonization. Carefully conducted large scale tests by the Fuel Research Station in England⁶ gave 1.4 gallons of light oil distilled from the tar and 1.6 gal. scrubbed from the gas—a total of 3 gal. per ton of coal. Fischer and Glund in Germany obtained 2.0 to 3.8 gal., and Davis and Parry⁷ of the Bureau of Mines obtained 4.5 gal. of light oil suitable for motor fuel from the low temperature distillation of a Pittsburgh district coal on a laboratory scale. These yields are of the same order as the benzol yields of high temperature carbonization. However, they can be augmented by the pressure cracking of the low temperature tars as shown by Morrell and Egloff⁸ who report a yield of 17 per cent of the total tar converted into oil distilling below 230 deg. C. Assuming an average yield of 25 gal. of tar, this would mean 4.25 gal. of motor fuel per ton of coal or a total of 6 gal. including that scrubbed from the gas.

Low temperature coke is not suitable for metallurgical purposes, hence the development of this industry will not reduce the amount of high temperature coke made. Its logical field is in the processing of our poorly coking and non-coking coals and lignites for the production of smokeless solid fuel. It is reasonable to expect in the relatively near future that 100,000,000 tons of bituminous coal, an amount equal to the annual anthracite production will be carbonized at low temperatures. This amount would yield 600,000,000 gal. of motor fuel, or about 8 per cent of the 1924 gasoline requirement. Another reasonable expectation is that super power stations will carbonize coal at low temperature, and generate steam from the pul-

²Fischer, Franz, *Liquid Fuels from Water Gas*, Ind. and Eng. Chem., vol. 17, No. 6, June, 1925, pp. 574-76.

³Mineral Resources for 1925.

⁴Bury, E., *Alcohol from Ethylene from Coal Gas*; Gas Journal 148, 718; Gas World 73, 123; Gas Journal 151, 449.

⁵Vallete, *Commercial Manufacture of Synthetic Alcohol*; *Chimie at Industrie*, 13, (1925), pp. 718-21.

⁶Fuel Research Board Report for the years 1920-21, Second Section: Low Temperature Carbonization (H. M. Stationery Office).

⁷Carnegie Institute of Technology, Bulletin 8, 1924.

⁸C. A., p. 1770; 2407 (1925).

verized residue. The 60,000,000 tons⁹ of coal burned in central power plants would thus provide 360,000,000 gal. of motor fuel which added to the yield from plants making domestic fuel would furnish a total of 960,000,000 gal., or 13 per cent of the annual requirement. Thus it is evident that the maximum possible development of flow temperature carbonization can not serve to furnish more than 20 to 30 per cent of the annual requirements, based on present day consumption. We must turn to processes in which motor fuel is one of the principal products rather than a minor by-product.

Motor Fuel from Bergius Process of Liquefying Coal.

Of these the Bergius process deserves serious consideration since it converts from 25 to 50 per cent of the coal into tar and oils, the yield varying with the type of coal and the conditions of hydrogenation. In this process, pulverized coal mixed with oil or tar to form a thick paste is heated at 400 to 450 deg. C. in an atmosphere of hydrogen under a pressure of 150 to 200 atmospheres of hydrogen. Under these conditions the coal is converted into a black, tarry liquid, which, on distillation up to 300 deg. C., yields oils and tar to the extent of 20 to 40 per cent according to various reports. No reliable information is available on exact yields or what proportion of this tar can be refined into motor fuel distilling under 150 deg. C. Kling¹⁰ reports 15 per cent. One of us who visited the plant at Rheinau a year ago was told that 20 per cent of the coal was converted into neutral oils boiling below 230 deg. C. and 10 to 15 per cent below 200 deg. C. On the basis of a 230 deg. C. end point gasoline, 1 ton of coal would yield 50 gal. It is claimed that retreatment of the heavier oil increases the yield of lower boiling constituents. Other investigators, notably Shatwell and Graham¹¹ in England, and Fischer and Frey¹² in Germany, have confirmed the essential facts of the Bergius process. Fischer and Frey working at 75-100 atmospheres at 425-450 deg. C. converted semi-coke from brown coal into oils and gas in 45.2 per cent and 30 per cent yields respectively.

We may therefore regard the Bergius process as one of the possible future methods for making a petroleum substitute from coal. But it must be emphasized that in this process, a gasoline substitute is only one of the products, the gasoline being in about the same proportion is in a light crude petroleum. From the standpoint of motor fuel production, the direct synthesis from gases seems more economical.

Synthetic Motor Fuel from Gases.

The investigations of Patart¹³ and Audibert¹⁴ in France, and of Fischer¹⁵ and the Badische Anilin and

Soda-Fabriken in Germany together with the production of methanol from carbon monoxide and hydrogen on a commercial scale by the latter has put a totally new outlook on the entire subject of our future motor fuel supply. In this process, pure methanol is produced from two volumes of hydrogen to one of carbon monoxide when subjected to pressures of 150 to 250 atmospheres and temperatures of from 300 to 425 deg. C. in a copper lined reaction chamber, containing one or more of a number of catalysts which include zinc oxide or oxides of chromium, vanadium, manganese, tungsten, uranium, lead and bismuth. The cost reported from both French¹⁶ and German¹⁷ sources varies from 18 to 27 cents per gal. About 18 per cent of the heat value of the constituent gases is consumed in the conversion. There are no by-products. On a volume basis, the net or low heating value of pure methyl alcohol is about 60 per cent of that of gasoline. Ricardo¹⁸ has shown that the indicated thermal efficiency at the highest useful compression for methyl alcohol is 35.0 per cent as compared to 31.4 per cent for gasoline at its highest compression—the compression ratios being 5.2 for methyl alcohol and 5.0 for gasoline. It should therefore require 1.5 to 1.6 gal. of methyl alcohol to be the fuel equivalent of one gal. of gasoline. One ton of coke should yield 350 gal. of methyl alcohol.

However, we need not confine ourselves to methanol, the experiments of Franz Fischer,¹⁹ Director of the Institute for Coal Research at Mulheim-Ruhr, show that fuel mixtures of higher heating value can also be synthesized from carbon monoxide and hydrogen. Fischer and his associates have produced on a laboratory scale from water gas a mixture which they term "synthol" that consists of a mixture of alcohols, aldehydes and ketones with small quantities of hydrocarbons. Water gas plus hydrogen is subjected to a pressure of from 75 to 150 atmospheres at 400 to 425 deg. C. in a steel reaction chamber containing a catalyst prepared from iron and a solution of sodium carbonate and consisting presumably of sodium ferrite. By-products of this reaction are carbon dioxide, methane and water. By recirculation of the gases, about one-third of the original water gas is converted into liquid products, having a distillation range similar to gasoline, and a heating value of 8200 calories per kilogram. This process is yet in its early laboratory stages, but it indicates that further developments along this line may be expected, especially since other laboratories both in the United States and abroad are taking up research in this field.

Economic Relationship of Motor Fuel Synthesis from Gas to Other Industries.

Assuming the feasibility and the development of synthetic motor fuel from gas, and granting that the day of universal use of composite fuels is coming, let us consider where these processes will fit into our present and future industries. Will the petroleum or the gas and coke industry be in the better economic position to make synthetic fuel?

⁹Patart, loc. cit.

¹⁰Elworth, R. T., Canadian Chem. Met. 9, 139 (1925).

¹¹Report of the Empire Motor Fuels Committee; the Inst. of Automobile Engineers, vol. 18, part I, (1923-24) p. 144.

¹²Fischer, Franz, Liquid Fuels from Water Gas; Ind. and Eng. Chem., vol. 17, p. 574 (1925).

(Concluded on page 148)

¹³Power, January 6, 1925, pp. 2 and 20.

¹⁴Kling, M. Andre, Liquid Combustibles from the Bergius Process, Chaleur at Industrie, Special Number, December 1924, pp. 53-71.

¹⁵Shatwell, H. G., and Graham, J. Ivon, The Hydrogenation and Liquefaction of Coal; Fuel in Science and Practice, vol. 4, pp. 25, 75, 127.

¹⁶Brennstoff Chemie 6, 69-79 (1925) C. A. 19, 1768.

¹⁷Patart, Georges, A New Field of Catalysis Under High Pressure: Commercial Synthesis of Methanol Chimie et Industrie 13, pp. 179-85 (1925).

¹⁸Audibert, Etienne, The Manufacture of Synthetic Liquid Fuels from Mixtures of Carbon and Hydrogen; Chimie et Industrie 13, pp. 186-94 (1925).

¹⁹Fischer, Franz, and Tropsch, Hans, Ueber die Herstellung von Synthol durch Aufbau aus Kohlenoxyd und Wasserstoff; Brennstoff-Chemie 4, 193; and 5, 201, 217.

Factors Affecting Selection of Fuel*

The Ultimate Choice Should Be Based on Cost per Unit of Goods
Manufactured, and the Various Secondary Advan-
tages of Convenience and Cleanliness

PROBABLY no problem of equal practical importance to a manufacturer is more difficult to solve than the selection of the most suitable fuel and furnace and the prediction of the results obtainable. Yet, the industrial gas man is continually being called on to do just that thing for it is his purpose to convince the manufacturer that gas is the fuel he should use. The basic principles of combustion are common to all fuels but the many differences in the details of their application dependent on manufacturing requirements render choice difficult, the more so, because there has always been a lack of experienced men who understand these fundamentals and can exercise judgment and discretion in making their decisions.

The very complexity that a close study of fuels reveals is also the reason for their varied usefulness. For example, each different use requires certain special properties in the fuel so that it shall be suitable for the installation at hand. Gaseous fuels have the widest range of adaptability without doubt, but their generally high cost has made adoption slow even where the local gas company has been progressive in furthering their use.

However, it is most important to emphasize that bare fuel costs are not and should not be determining factors in influencing fuel selection. The ultimate choice should be based, first, on the cost per unit of goods manufactured, and second on the various secondary advantages of convenience and cleanliness to which it is often difficult to assign a direct value but which nevertheless are most important.

In general it is the use to which a fuel is to be put that dictates the choice. But, in heating operations where more than one fuel can be used, due consideration should be given to all the factors just mentioned. Furthermore, it is to be noted that while natural fuels exist in great variety, it is both good engineering and in the interests of conservation of our natural resources to manufacture other fuels from them, thus besides securing two heating fuels, gas and coke, we save most valuable by-products. These facts indicate that the relative merits of the various fuels should be studied quite closely and the first step towards this end is a classification of fuels as shown in Fig. 2.

Fuels, as indicated, can be solid, powdered, liquid, gaseous or delivered in the form of electrical energy directly available for use. The efficiency of their utilization on a Btu. basis is not a constant but varies with temperature of operation, design of furnace, actual operation conditions as well as other lesser factors. It is important in this connection to avoid the unfair but common practice of crediting a fuel for improvements resulting when a cheap, unsuited, inefficiently run furnace is replaced by an efficient, specially designed apparatus expertly operated on another fuel. This procedure has frequently resulted in the selection

of very expensive fuels, particularly electricity, to perform heating operations more efficiently, comparing the results as found in practice and neglecting the fact that the same result could be accomplished with the cheaper fuel if the same care and thought were given to the design of its furnace as is given, for example, to electrical equipment. As one prominent furnace maker has aptly stated, "There is no one type of furnace or form of heat energy (combustible or electric) that has a monopoly on uniformity of heating or economy of operation."

Even though, from the viewpoint of thermal efficiency, much depends on the furnace, yet one fuel can be inherently better than another because of its physical properties. Of all the fuels gas possesses the most advantages, some of which are reiterated below.

1. Combustion is easily controlled, the atmosphere can be kept oxidizing, reducing or neutral, as desired. It is free from sulphur compounds (traces only, allowed by legal standards) rendering it very suitable for direct fired metallurgical operations.

2. Flexibility of gas as a fuel is evident, turn of a valve and an unlimited supply of heat is available. In event of coal shortage, public utilities get priority orders.

3. Temperature control can be affected through pyrometers or for low temperatures by direct acting thermostats.

4. Gas requires no storage space. Coal yards occupy costly space; oil storage requires costly tanks and generally increases the fire risk.

5. Gas burns clean, no smoke, no soot, no ashes.

In the selection of fuels, not only the fuel but also the furnace merits special attention and study. Consider then some of the outstanding features of good furnace design so that an intelligent selection can be made from the great number of types available. The chief points to consider in good furnace design include the following:

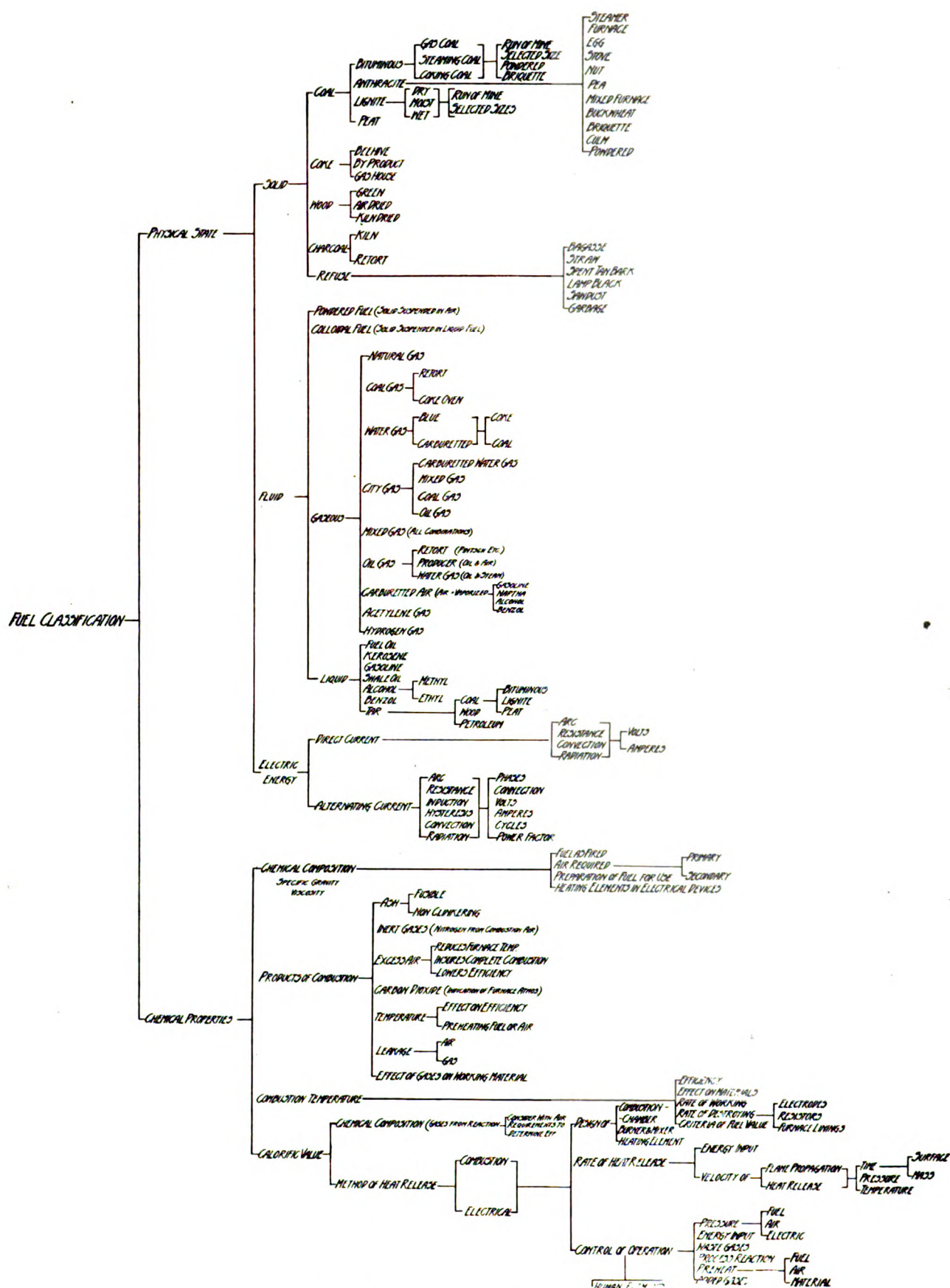
- a. Wherever possible continuous furnaces with counter-current flow of heat and materials should be installed because these not only have the greatest capacity for a given space but also the best fuel economies. The choice is influenced by the size, shape and weight of materials being heated; by the quantity and rate of movement through the heating chamber.

- b. Automatic temperature control not only insures uniform results but will yield better operating efficiencies than are possible with manual control.

- c. Greater attention paid to the methods of utilizing the available heat will repay itself many times. Perfect combustion, good insulation, no leakage losses are all elements of great importance. In continuous ovens considerable heat is often carried away by the conveying mechanism.

- d. Structurally, the design of gas furnaces has not always been as satisfactory as could be desired. First cost is not so important in furnace design as permanency and freedom from repairs. Special attention

*From a book prepared by the Industrial Gas Section of the American Gas Association.



should be given to the refractory linings for high temperature work.

e. Finally working conditions must be considered for these influence both choice of furnace and the results obtainable. The selection of a furnace resolves into a compromise. The better furnaces are high in first cost, repairs are less frequent but more expensive, floor space occupied is large; on the other hand their operation is satisfactory and efficient, the quality of the product is good and better shop conditions prevail.

f. In all of the discussion of fuels and furnaces, the importance of skilled operatives must be carefully considered. Given the best of equipment, the most efficient fuel, and as much automatic apparatus as human ingenuity has been able to devise, the human element must still be dealt with and its effect upon the nature of our product, an effect which, in many cases, is allowed to be most detrimental, merely because the shortsightedness and false economy of the management has prevented the employment of a man who knows his tools — the furnace and the fuel. It is a waste of money to install highly efficient furnaces equipped with pyrometers and heat salvage devices, all of which are obviously expensive, without providing adequate intelligent supervision, capable of observing and maintaining the quality of the product.

Figs. 1 and 2 which summarize the more important factors governing the selection of fuels and furnaces are adapted from similar charts furnished through the courtesy of the W. S. Rockwell Company of New York.

Relative Thermal Efficiency.

It is a well known fact that most industrial heating processes are carried on at fuel efficiencies far below the values obtainable and insisted upon in other operations of equal importance; particularly is this so, because, in this country at least, but little attention has been given to the advantages of heat saving devices. The solid fuels require considerable excess air for combustion, limiting the maximum possible efficiencies right from the start. The liquid fuels too, require excess air, although not as much as the solid ones. Only gas can be operated on the theoretical quantities required. If the flue products leave at a sufficiently low temperature, the heat in the flue products can be recovered, but with solid fuels stack temperatures must be maintained in order to secure the necessary draft. Thus, even at low temperatures only comparatively low efficiencies are obtainable. At higher temperatures the effects become more and more marked because not only do the flue losses increase but also the radiation, leakage and other less important losses.

So many factors influence the efficiency of a furnace, the total useful heat available and the temperatures attained, that the prediction of the results with accuracy is a very difficult problem especially when dealing with recuperative systems.

In the above discussion electricity as a heating medium has been omitted for which extravagantly high efficiencies are often claimed. Efficiency is not a function of the fuel so much as of its method of utilization. Electricity, for example, can be used in heat treating furnaces at very high efficiencies if the furnace is perfectly insulated, the work continuous and of such a nature that the time consumed for each batch is comparatively long and if the doors and other

openings fit tightly. On the other hand not much better than 50 per cent of the results under the above conditions could be expected if the work is intermittent, if the doors must be opened frequently, thus producing the equivalent of an "excess air" loss in combustible fuels, if insulation is not perfect or if any detail of construction and operation has not been most carefully considered.

And so with other heating methods whether coal, coke, oil or gas is the fuel. Operation and construction often count for more than the fuel. However, considering successively various major heating operations such as: baking at 450 deg. F.; heat treating at 1,600 deg. F.; forging at 2,300 deg. F.; and metal melting at 2,800 deg. F.; it will be found that the maximum possible efficiencies obtainable with different fuels rapidly diverges. Therein lies a big advantage to a fuel whose cost on a Btu. content basis is as high as gas but whose usefulness increases the higher the operating temperature. Considering the advantages of recuperation in increasing flame temperatures and efficiency the opportunities that are still open for the further extension of gas as the ideal fuel can be realized. It has been noticed that the value of the fuels diverges as the temperature rises. The theoretical thermal efficiency of gas decreases slowly enough to offset the initial price advantage of coal or oil, particularly if in the future better equipment becomes available and heat saving devices are adopted. The applications of electricity, too, are being extended very rapidly; and if the cost of electricity decreases sufficiently, a point may be reached where the comparative cost even on a Btu. basis will not be unfavorable to electric heat. As a matter of fact for the highest temperatures such a comparison even at present prices may not be entirely unfavorable. However, here lies the opportunity of the progressive gas man to firmly establish gas as the industrial fuel, now—to induce manufacturers to heat by gas, not by selling them the cheapest equipment, but by selling the best and most efficient.

Gas, as the agent for all industrial heating, is waiting ready to be eagerly used as fast as trained men are available to solve the problems that still are hindering development. Every manufacturer wants for his shops modern, efficient methods, speeding up his production and relieving his workmen of as much drudgery as possible. For this no greater or better medium than gas is available.

Cost Curves and Their Use.

Determining what the cost of a particular operation would be, using some other fuel and at some other efficiency value is only a matter of elementary arithmetic, but for greater convenience Chart I has been plotted. This comparative fuel cost chart gives the cost of 100,000 effective Btu. derived from coal, oil, gas, or electricity for any efficiency value. Coal of 12,500 Btu. per lb.; oil of 20,000 per lb.; gas of 550 Btu. per cu. ft. and electricity with 3,412 Btu. per kwh., have been taken as a basis for these curves. The several curves for each fuel are designed to cover a wide range in price; coal from \$5 to \$20 per ton of 2,000 lbs.; oil from 5c to 20c per gallon; gas from 50c to \$2.00 per M. cu. ft.; electricity from 1c to 10c per kwh. If the particular fuel costs in question fall between the plotted values it is an easy matter to interpolate, the curves being in direct arithmetical ratio to one another.

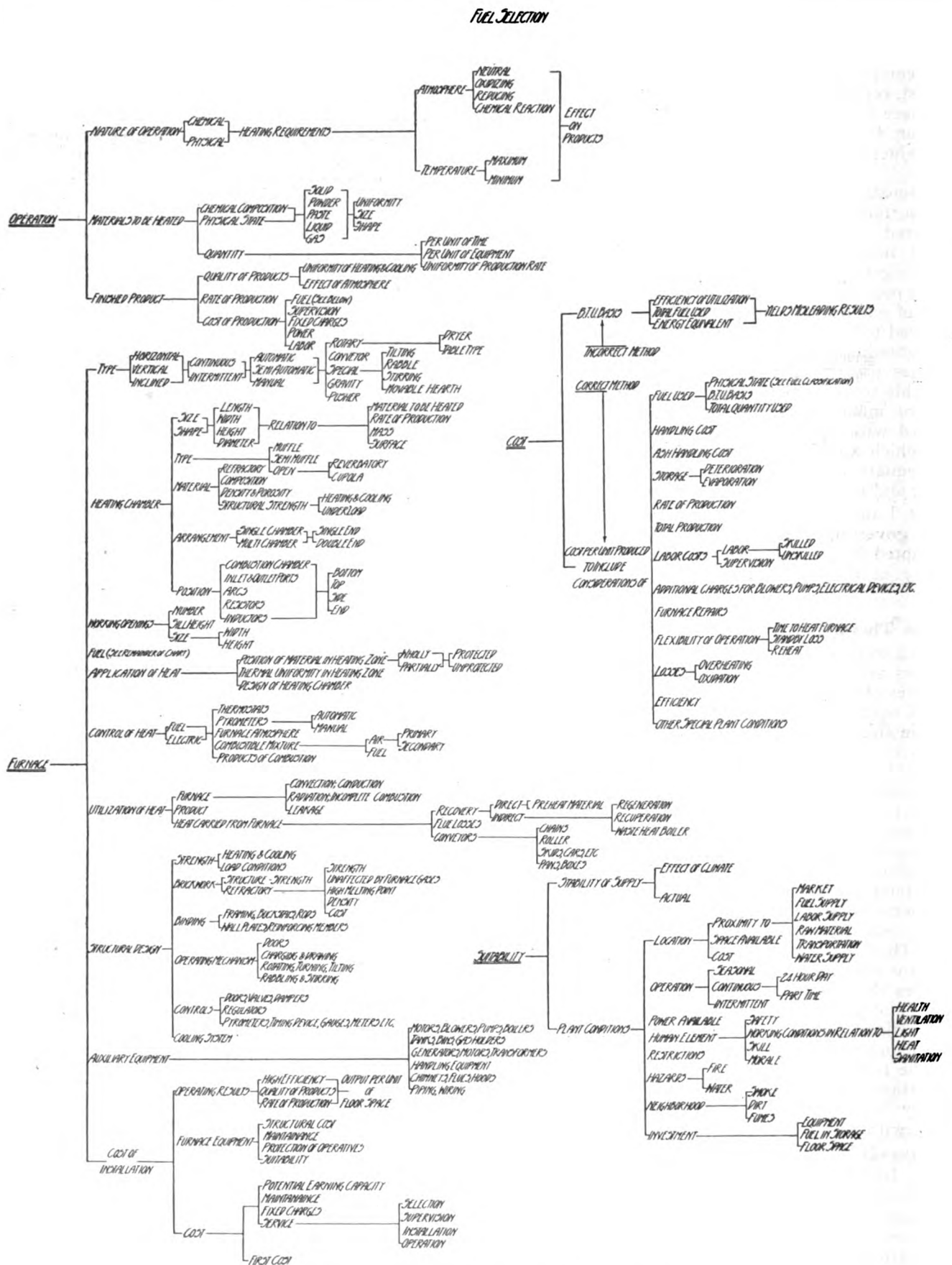


FIG. 2—Factors affecting the selection of furnaces.

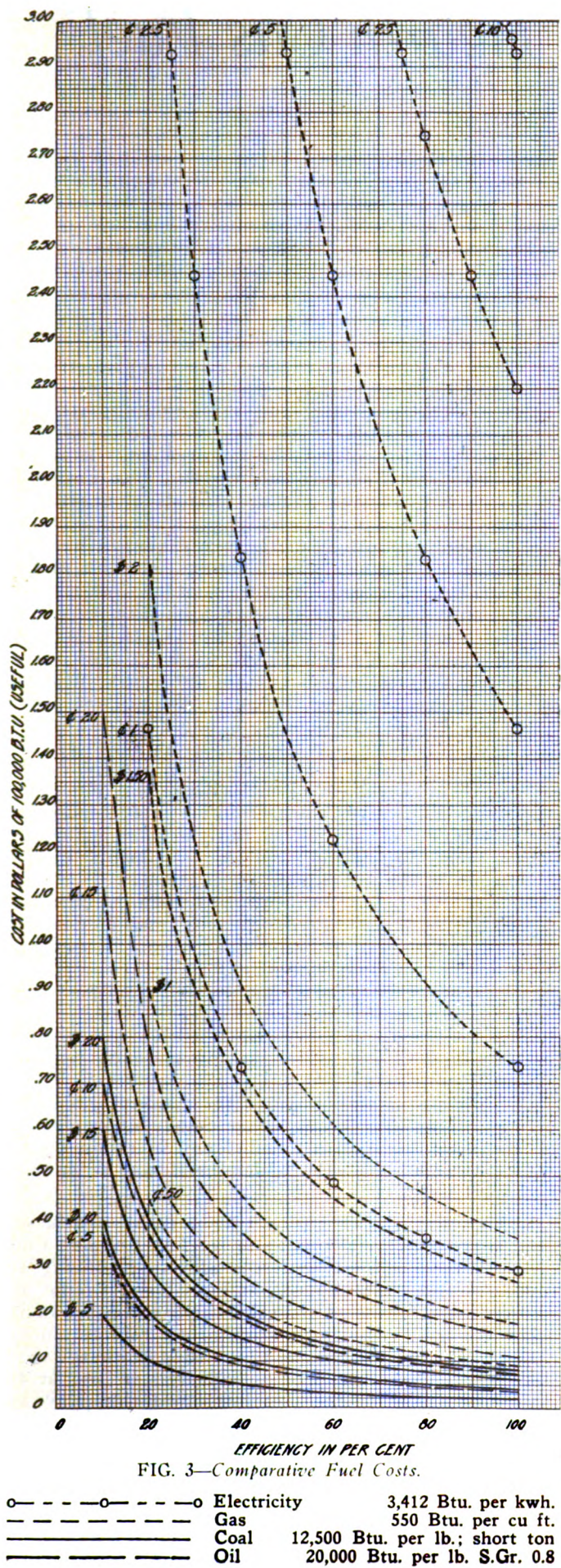


FIG. 3—Comparative Fuel Costs.

The use of these curves can best be illustrated by an example:

Example 1. What would be the relative cost of heating a forge by gas, coal and electricity?

Gas efficiency 30%	Cost \$1.25 per M.
Coal efficiency 12%	Cost \$15.00 per ton
Electricity efficiency 65%	Cost 2½c per kwh.

From curves

Gas would cost	\$0.75 per 100,000 Btu.
Coal would cost	.50 per 100,000 Btu.
Electricity would cost	1.13 per 100,000 Btu.

It is necessary to establish approximate efficiencies for different industrial processes so that comparisons can be made. These curves are applicable to any fuel cost comparisons irrespective of the use of the fuel.

In order to determine relative fuel costs and to find ways and means to convince the customer that gas is his best fuel it is often necessary to analyze his existing fuel efficiencies in order to find out where the greatest room for improvement exists. Each individual heating operation will be found different from the others, and as such, should be separately treated, rather than to apply the easy comparative fuel efficiencies so often given in the handbooks for selecting the right fuel. Consider, therefore, how to find the fuel efficiency of a given process.

By overall efficiency is meant the ratio of $\frac{\text{Output}}{\text{Input}}$

which can be expressed as:

$$\frac{(\text{Lbs. of material heated}) \times (\text{Temp. rise}) \times (\text{Mean Sq. Heat})}{(\text{Quant. of fuel needed to heat material}) \times (\text{Btu. value of fuel})}$$

The efficiency on this basis gives no indication of how the difference between total and useful heat is lost. In fact the only item in that difference which can be determined with even a semblance of accuracy is the flue products loss. The loss from conduction and radiation is most difficult to determine. The amount of heat required to bring the furnace to temperature can only be roughly approximated.

To calculate or predict what could be done with gas in an existing installation involves knowing the appliances which will be used. In a conversion, however, the following can be assumed:

First, unless the insulation can be improved, which is often very vital, the radiation loss is likely to be the same as it was before conversion. The insulation, therefore, should be given careful consideration. The electrical people have developed the insulation of their equipment so far that one can conveniently lay their hands on the outside of furnaces in which the temperature is above 2,000 deg. F. Initial expense in this item soon will pay for itself.

Second, the flue gas loss can be reduced to a minimum with gas by keeping a neutral atmosphere and approaching as near to perfect combustion as possible. To save the heat in the flue products at high temperature use ample size recuperators and cut down this loss as far as possible. Improvements in efficiency represent corresponding savings in fuel consumption and, therefore, reductions, in the cost of the process, provided, of course, that the cost of improving the efficiency is not greater than the savings effected.

Third, automatic temperature controls yield better economy than manually operated furnaces. Pyrometers are not for laboratory use only. They are essential, practical parts of every installation.

Purification of Open Hearth Gas Fuel*

By F. W. SPERR, JR.†

PART I

SINCE the organization of the Research Laboratories of The Koppers Company 10 years ago, one of the prime objectives of our research has been to improve purification of gas. The characteristic impurities of artificial gas include ammonia, tar, naphthalene, gum-forming hydrocarbons, water, oxygen, carbon dioxide, hydrocyanic acid and sulphur compounds. Of these, the sulphur compounds are so important that the gas man always understands gas purification to mean the removal of sulphur. This has naturally been given primary consideration in our research program, and the result has been the successful practical development of "Liquid Purification." This means the removal of sulphur by treating the gas with a liquid reagent instead of dry iron oxide which was previously the universally employed purifying material. There are now more than 40 Koppers Company's liquid purification plants in the United States and Canada and some installations have been made in Europe.

The value to the steel industry of the removal of sulphur from open hearth fuel gas has been an important consideration in this work. One of the earliest liquid purification plants furnished by The Koppers Company was for the use of the Crucible Steel Company of America in purifying coke oven gas used in its open hearth furnaces at Midland, Pa. This plant has been in operation for nearly three years and the results have been so satisfactory as to warrant the conviction that the purification of all coke oven gas for open hearth fuel is entirely feasible and economical and will soon be regarded as a necessity.

In artificial gas, the bulk of the sulphur occurs as hydrogen sulphide. In addition to this, there is always some organic sulphur, principally carbon disulphide. This organic sulphur is usually very small in amount and may be disregarded by the steel works man. In coke oven gas, such as would be produced from Pittsburgh coal, the organic sulphur should not exceed 3 per cent of the total sulphur.

Until recently, the absorption of hydrogen sulphide was accomplished by dry absorbent material. Up to about 40 years ago, lime was generally used. This, however, was entirely displaced by hydrated iron oxide which is the standard dry purifying material of today. The cumbersome nature of the apparatus and methods required by dry purification has hitherto been largely responsible for deterring consideration of the removal of hydrogen sulphide from open hearth fuel gas. The iron oxide is mixed with some bulky material, such as wood shavings or ground corncobs, and the mixture is placed in large steel boxes through which the gas passes. In order to make the process economical, the used oxide must be removed from the boxes, spread out in shallow layers and exposed to the air for revivification, and then

used over again, two or three or more times. The ground area required for boxes, revivification space, and storage of oxide is very large. A dry purification plant for 20,000,000 cu. ft. of coal gas per 24 hours requires about 90,000 sq. ft. of ground.

The principal disadvantages of dry purification from the standpoint of steel works requirements may be summarized as follows:

- 1—Large ground area required.
- 2—Apparatus is expensive in comparison with liquid purification apparatus.
- 3—The emptying and refilling of boxes and the revivification of the spent oxide involves a large and irregular labor requirement. It is uneconomical to empty and refill a box until the oxide is exhausted and the periods of exhaustion vary considerably.
- 4—Operation of oxide boxes always involves risk of explosion. Several serious accidents of this sort have happened in the past few years. Explosions may occur through admission of air to the boxes for "revivification in situ," through spontaneous ignition of the oxide in presence of explosive mixtures of gas and air when the boxes are being opened or through other causes.
- 5—For best economy in oxide purification, it is desirable to admit some air with the gas for continuous revivification in order to prolong the period of usefulness of each charge of oxide. This, however, involves some attention and expense and the excess of oxygen in the gas is objectionable as being one of the elements responsible for corrosion in the subsequent apparatus.
- 6—An oxide purification system is comparatively rigid as regards capacity and is not well adapted to handle wide fluctuations of gas volume and sulphur content.
- 7—Dry boxes are not feasible for gas under any considerable pressure.
- 8—The oxide offers considerable resistance to the flow of gas which means increased expense for pumping.

From the standpoint of the artificial gas industry, there are certain other disadvantages of dry purification, such as inefficiency in removing hydrocyanic acid, etc., which need not be enumerated here.

The first liquid purification process which was put into commercial operation by The Koppers Company was developed with the idea of removing the bulk of the hydrogen sulphide by very simple and inexpensive means so that the sulphur content of the gas would be reduced to a uniformly minute amount which would be extracted in the ordinary oxide boxes. This is the process which is in use at the Midland Plant of the Crucible Steel Company and which, it is believed, should be best adapted for most steel works purposes. It has often been spoken of as the Seaboard Process and will be so designated here to distinguish it from other processes.

In the Seaboard Process, most of the hydrogen sulphide which is removed from the gas is expelled

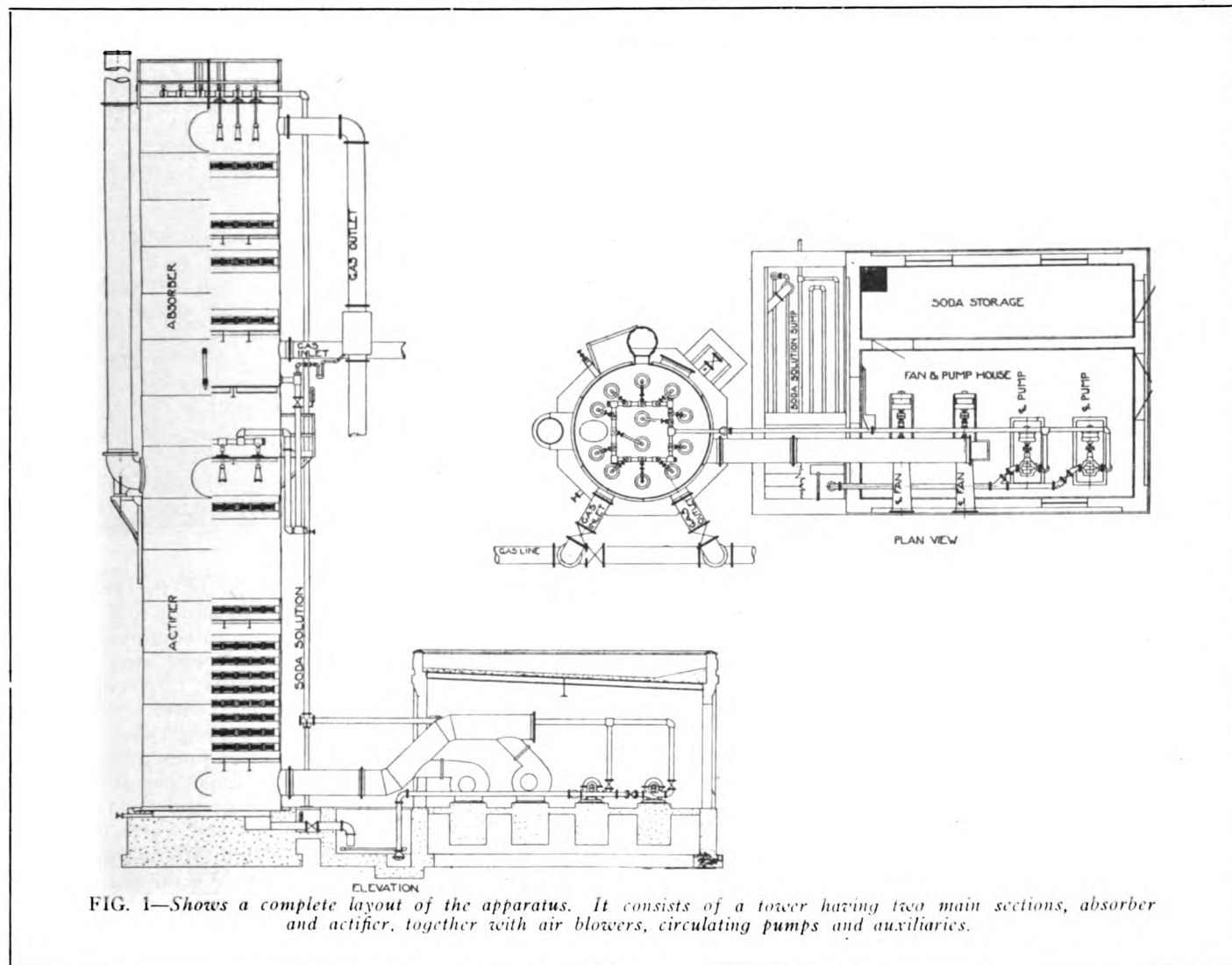
*Part of the material in this paper was presented in an address before a meeting of the Eastern States Blast Furnace and Coke Oven Association, in Youngstown, Ohio, June 4, 1925.

†Director of Research, The Koppers Company, Pittsburgh, Pa.

into the atmosphere in the process of revivifying or "actifying" the absorbing solution. The hydrogen sulphide thus expelled is highly dilute, but under certain conditions its characteristic disagreeable odor can be detected and under certain conditions this odor may be sufficient to be objectionable. This is the only drawback to the universal application of the Seaboard Process, which in other respects is ideal from the standpoint of simplicity and economy.

The further developments of The Koppers Company in liquid purification were actuated by the ideas of eliminating the odor trouble, recovering the sulphur in salable form, and accomplishing complete in-

hurdles. The absorbing medium consists of a dilute solution of sodium carbonate (commercial soda ash) the ordinary strength of which is equivalent to from 1 to 3 per cent Na_2CO_3 . This solution is pumped from a sump over the absorber from which it flows by gravity into the actifier and thence back to the sump. The gas passes through the absorber in intimate contact with the solution which removes 85 per cent to 95 per cent of the hydrogen sulphide and hydrocyanic acid together with a smaller percentage of the carbon dioxide. Extraction of additional amounts of these impurities may be accomplished by a further scrubbing operation, but a single scrubbing



stead of partial purification. The result has been the development of what we may designate as the Sulphur Recovery Process which is now in its second year of operation in a large demonstration plant, operated for the Seaboard By-Product Coke Company, and which has recently been put into operation for the St. Louis and Detroit Gas Companies.

Fig. 1 shows the apparatus usually installed for operation of the Seaboard Process. It consists of a tower having two main sections designated as the absorber and the actifier, together with air blowers, circulating pumps and other minor auxiliary apparatus. The absorber and actifier are filled with suitable packing, e.g., coke, spiral tile, or wooden

is ample for any steel works purposes, and in most gas plants the small amount of hydrogen sulphide remaining is removed in iron oxide catch boxes.

The solution containing the absorbed impurities flows down through the actifier through which air is blown by a fan. The volume of air required is from two to three times the volume of gas purified. The air removes the hydrogen sulphide and regenerates the solution so that it can be used over and over again. Some soda is used up in the formation of sodium thiosulphate and sodium thiocyanate and in mechanical losses, but the amount so consumed is very small. The usual consumption of sodium carbonate in the purification of coal gas is about 1 pound

for every 8 pounds of hydrogen sulphide removed, some plants, however, showing much lower soda consumption figures than this. The sodium thiosulphate and sodium thiocyanate are extremely soluble and build up in the solution until their rate of formation is compensated by the rate of mechanical loss, after which the solution continues in practical equilibrium for almost indefinite periods. Periodical additions of soda and sometimes of water are required, but ordinarily no solution is discarded.

(To be continued.)

The Foxboro Company, Inc., of Foxboro, Mass., makers of indicating, recording and controlling instruments, have announced the change of address of their Pittsburgh office. Formerly located in the Park Building, the company have moved this office to what will now be known as the "Foxboro Building," on the corner of Sixth Avenue and Grant Street. The four upper floors of the building will be utilized for offices and the maintenance of a substantial stock of new instrument equipment, including Flow Meters, Indicating and Recording Gauges and Thermometers, Controllers, etc. The central location of this building should prove of exceptional advantage. Mr. H. S. Gray continues in charge of the Company's Pittsburgh branch.

Dr. Thomas T. Read, well-known mining engineer of Washington, D. C., and director of the Safety Service of the U. S. Bureau of Mines, has been chosen by the board of directors of the American Institute of Mining and Metallurgical Engineers to act as assistant secretary of the Institute, with headquarters in New York. Dr. Read is a prominent figure in the mining educational field, having taught in the University of Wyoming, Columbia University, Colorado College, and Pei Yang University, Tientsin, China. He has acted as associate editor of the "Mining and Scientific Press," San Francisco, and is the author of treatises on "Recent Copper Smelting" and "Mineral Resources of the Chinese Empire" and more than a hundred technical articles on various mining and metallurgical subjects.

Complete Utilization of Coal and Motor Fuel

(Continued from page 140)

The Petroleum Industry and Synthetic Fuel.

Since the waning of petroleum gasoline will be a gradual process, it would seem logical for the large petroleum refiners to install synthetic processes to augment their gasoline supply just as some of the natural gas companies are now adding water gas to their natural gas to make up the required volume. The large refineries have the organization, financial resources, and the distributing systems to market the fuel. The methanol and synthol processes are peculiarly adapted to this purpose since the entire product can be converted into motor fuel.

The Manufactured Gas Industry and Motor Fuel.

However, the petroleum industry is likely to have strong competition from the manufactured gas industry which has an inherent economic advantage in that they are engaged in the manufacture of water gas, the raw material for methanol and "synthol."

The summer months when the need for motor fuel is greatest is the period when gas plants have much idle capacity which must be maintained to carry the peak loads of the winter season. The addition of synthetic motor fuel units would serve to give an even load and at the same time permit the unhampered development of domestic house heating, which at the present time is increasing the top-heavy winter loads.

The gas utility companies also have natural advantages in selecting the most economic process for providing the necessary constituent gases and in disposing of residual gases from the process. For example, in making methanol, they manufacture the coke for making the water gas in by-product ovens, separate the requisite extra volume of hydrogen from the coke oven gas, and use the remaining high Btu. rich-in-methane gas for enriching water gas for city distribution. Such enrichment will be needed to take the place of the present day oil carburation. The ethylene can also be converted to ethyl alcohol which, with the benzol from the coke ovens, can be mixed with the methanol for motor fuel.

The public utilities distributed in 1924 some 500,000,000,000 cu. ft. of manufactured gas, of which 74 per cent was carburetted water gas. The estimated annual idle capacity of these water gas plants is 350,000,000,000 cu. ft.²⁰ This amount of gas will produce 1,500,000,000 gal. of methanol or 300,000,000 gal. of the mixture "synthol." Fifteen hundred million gallons of methanol is 13 per cent of the 1924 gasoline consumption. The inevitable growth of the gas industry will provide a much larger capacity and the expansion required to take care of the entire demand is a distinctly practical possibility.

Conclusion.

Before concluding this review of the relation of the complete utilization of coal to motor fuel, we wish to state that our discussion has been confined solely to liquid substitutes from coal for petroleum gasoline that can be used in essentially similar internal combustion engines. We recognize that Diesel type engines using heavier oils, gas producers using coke and semi-coke, and even compressed gas engines may be used, especially on trucks. But the most promising solution of the motor fuel problem of the distant future is in the synthesis from coal gas and water gas, since there are no inherent quantity limitations imposed by the market for other products. We do not mean to say that any large amount of substitute will be needed for gasoline in the near future. We may need some substitutes in 5 years, or it may be 25 years. However, we know that the time for research is here. The French government has already established a laboratory for motor fuel research. The German government and the coal industries are jointly financing similar research.

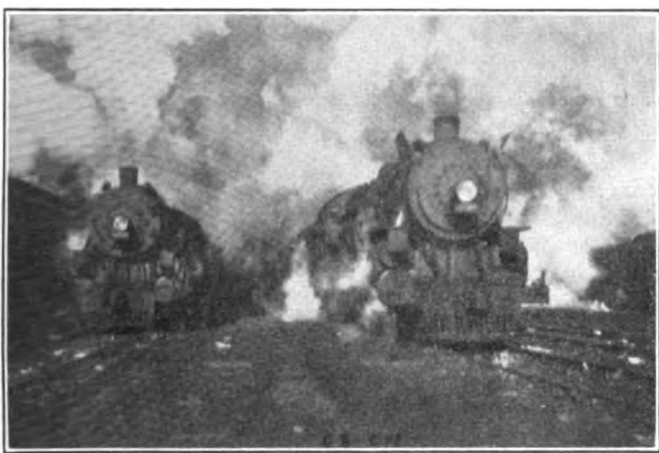
The Fuel Research Station in England is investigating the hydrogenation methods, and some of the petroleum and automobile industries in this country are at work on the problem. Our own coal and gas industries are not yet in the field. We hope that they too will lend their support to American chemists so that our country can maintain its commanding position in the field of motor fuels.

²⁰Personal estimate.

Electrical Transmission of Pictures

Since telephotographs—pictures transmitted by wire—were introduced to the business world about two years ago at the Republican National Convention, one business house after another has been awakening to the possibilities of this new development in communication, until today widely varied interests are creating a demand for the service.

By the use of telephotographs, Blyth-Witter & Company, New York, were able to save eleven days in the floating of a stock issue, and were thus enabled to meet a favorable market. On a recent Sunday morning their San Francisco office obtained the approval of their attorneys to a new stock circular. At the same time the Security Bank Note Company, printers of financial paper, obtained approval for the stock certificate model from their San Francisco attorneys.



Telephotographs of the circular and certificate were sent simultaneously to Chicago and New York on Sunday afternoon. Because of its length it was necessary to send the circular in sections. As soon as each part was received a messenger boy rushed the telephotograph, still damp from the photographic process, to the printer, who set up the type and printed the circulars. Monday morning the circulars were at the San Francisco, Chicago and New York offices of Blyth-Witter & Company.

Meanwhile at New York two prints were made of the stock certificate telephotograph. One was mailed to the bank note company's printing plant at Philadelphia, and the other to the vice president of that company at New York.

Approval of the stock certificate was obtained from the stock exchange about Monday noon. Philadelphia was called by long distance telephone and told to print the certificates with modifications as suggested by the listing committee.

On Thursday night 10,000 certificates, sent from Philadelphia by aeroplane mail, were delivered at the San Francisco office of Blyth-Witter & Company. All this was accomplished in the time it would have taken the regular mails to come from San Francisco to New York.

Another striking example of the use of telephotographs to save time and expense is illustrated by the experience of a large eastern industrial corporation. A conference of the executives of the business had been called to meet in New York to discuss an im-

portant contract. On the day prior to the conference it developed that the only obtainable copy of the contract was in San Francisco. To wait for a facsimile contract, sent by the fastest mail service, would have meant the loss of valuable time. But a telephotograph of the contract was sent from San Francisco to New York and delivered one hour before the meeting was held.

One of the large oil companies has found an important use for telephotographs in its accounting department. It is the monthly custom of the Pacific coast offices of this company to send their balance sheets to the office in San Francisco. Here they are combined and a trial balance sheet sent to the main office of the company in New York City. This trial balance sheet is now sent by telephotograph, hastening its arrival at New York by at least three days. The company is thus able to issue its monthly financial statements several days earlier than formerly.

Pictures of news events are being telephotographed across the country almost daily. A photograph originating in San Francisco will appear in the San Francisco, Chicago and New York newspapers on the same day.

In addition to these cases, uses for telephotographs are coming to light in an almost unlimited field. Among the suggested uses are: Portraits of any size or kind, pictures of celebrities figuring in the news of the day, scenic views from distant points, mechanical drawings, pictures of machinery, either the entire unit or any of its parts, up-to-the-minute fashions, sports contests, advertising layouts and proofs, checks and other financial papers, X-ray pictures and electrocardiographic tracings, textile designs, wills and similar legal documents.

Fifty years ago the telephone stood on the threshold of business just as the telephotograph stands today. Thousands of people now living have witnessed the phenomenal growth of local and long distance telephony. Who will venture to predict the diverse uses made of the electrical transmission of pictures fifty years hence?

Motobloc

The Vaughn Machinery Company of Cuyahoga Falls, Ohio, have recently published an interesting bulletin. It is titled "Motobloc," and in its foreword refers to equipment furnished the Cleveland Rolling Mills in 1870. The outstanding features of the Motobloc are:

- 1—Adjustable working speeds over a wide range, secured through an adjustable speed direct current motor and a simple and rugged control.
- 2—Very slow starting or pulling-in speed regardless of final working speed.
- 3—Worm gearing accurately machined and enclosed in an oil tight casing.
- 4—Ball or roller bearings on main shafts (optional on motor).
- 5—One-piece at base plate for each unit, supporting main frame, motor and control, all above floor line.
- 6—Stripper blocks, designed for use with block strippers and cranes.
- 7—Positive, easily operated, fool proof electrical safety devices.

Professor James Aston

James Aston of Pittsburgh, for the past five years metallurgical engineer in charge of research with the A. M. Byers Company, has been appointed Professor of Mining and Metallurgy and head of the Department of Mining and Metallurgical Engineering of Carnegie Institute of Technology. Announcement of the appointment was made by President Thomas S. Baker January 26 at the meeting of Metallurgical Advisory Board held at the Pittsburgh Station of the U. S. Bureau of Mines in connection with the formal opening of the new ferrous-metallurgical research laboratories.



JAMES ASTON

The appointment, which is effective February 1, fills the vacancy caused by the death last February of Professor Fred Crabtree. Professor F. F. McIntosh, who has been in charge of the department as acting head since Professor Crabtree's death, it was also announced, has resigned effective February 1 to accept an important position with the Crucible Steel Company.

Mr. Aston, who has served as a member of the Advisory Board of prominent representatives of the metallurgical industries of the Pittsburgh District, and which co-operates with the Carnegie Institute of Technology and the U. S. Bureau in conducting research in metallurgy, was born in England in 1876, and was brought to this country when three years old. Most of his youth was spent in Milwaukee, where he attended high schools, and was graduated in 1898 from the University of Wisconsin with a B. S. degree in Electrical Engineering.

After a year's work in electrical engineering, Mr. Aston became interested in the metallurgical side of business in foundry work. In 1908, he returned to the University of Wisconsin to do research work on

electro-iron and alloys under the supervision of Professor Burgess who had received a grant from the Carnegie Institution in Washington. After spending his entire time for a year in research, he added to his duties instructional work in chemical engineering, specializing in metallurgical work. After four years at Wisconsin, he went to the University of Cincinnati to do analytical work in metallurgy and later received the professional degree of chemical engineer from Wisconsin University.

Mr. Aston remained at Cincinnati University four years, leaving to take a position as metallurgist at the Pittsburgh Station of the U. S. Bureau of Mines. In the fall of 1915, he joined the A. M. Byers Company as metallurgical engineer in charge of research.

He is a member of the American and British Iron and Steel Institutes, American Electro-Chemical Society, American Society of Mechanical Engineers, American Society of Testing Materials, and the Engineers Society of Western Pennsylvania. His fraternity connections are with Sigma XI, Alpha Chi Sigma, Phi Lambda Upsilon, and Tau Beta Pi.

Mining and Metallurgical Medal

Announcement of the proffer of funds by William L. Saunders prominent mining engineer, for the establishment and support of a gold medal to be conferred annually in recognition of achievement in the field of mining was made at the annual meeting of the board of directors of the American Institute of Mining and Metallurgical Engineers in New York. Acceptance of the offer was voted, and a committee of well-known mining technologists will be appointed to formulate the terms of the award.

While there are various medals or prizes bestowed annually in recognition of achievement in metallurgy, chemistry and other branches of scientific research, the establishment of the Saunders medal constitutes what might be termed the premier endeavor to accord such honors to technical workers in the general field of mining, and it is anticipated that the medal will in the future rank as a coveted honor in the scientific world. The terms of the award have been purposely left quite broad in order to give the committee full latitude in the selection of the subjects to be made the basis of the bestowal.

Mr. Saunders, donor of the fund for establishment of the new medal, is one of the best-known mining engineers in the United States. He is president of the United Engineering Societies, whose membership is made up of the big engineering organizations in the mining, mechanical, electrical and other fields. He is a past president of the American Institute of Mining and Metallurgical Engineers, and of the American Manufacturers' Association; is a member of the Naval Consulting Board, and a member of numerous other industrial and scientific organizations.

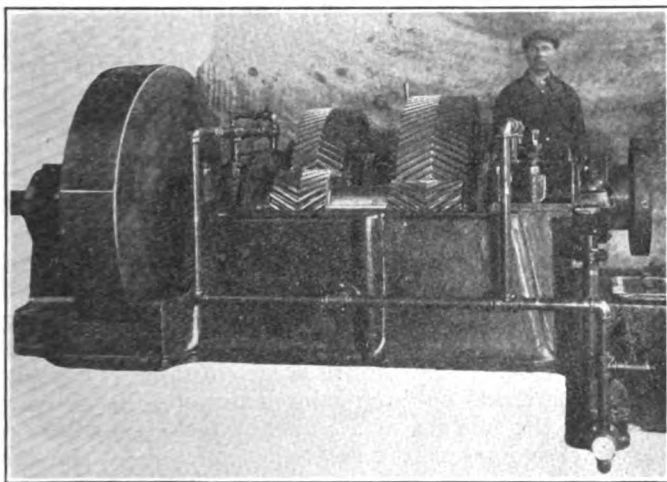
Mr. Saunders is internationally known in connection with his achievements in compressed-air engineering and in the design of rock drilling and quarrying devices. He is author of a number of treatises and papers dealing with these subjects. He is president of the Ingersoll-Sergeant Drill Company and the Rand Drill Company, chairman of the board of directors of the Ingersoll-Rand Company, and director of various other industrial enterprises.

WITH THE EQUIPMENT MANUFACTURERS

New Two-Speed Rolling Mill Drive

The Farrel Foundry & Machine Company, Buffalo, N. Y., have developed, during the past year, a two-speed gear drive for rolling mills.

The illustration shows one of these drives which is being supplied to the Latrobe Steel Company. It is designed to transmit 500 hp. with motor speed of 860 rpm. and to give a high speed of 275 rpm. to the mill and a low speed of 165 rpm. It is in use on a 10-in. bar mill, used for rolling high speed tool steel. The desirability of a variable speed drive for a bar mill is well understood and it is relatively common to employ for this purpose a variable speed motor. Such motors with the necessary control apparatus are expensive. The new gear drive allows the use of a standard motor which can run at a relatively high speed. The flywheel on the pinion or motor shaft can be designed for the high speed of the motor instead of for the low speed, as is necessary when a variable speed motor is used. This saves expense and results in better operating condition, because the flywheel is



always working at maximum speed and, therefore, it is always capable of storing or giving out the maximum amount of energy in proportion to its weight.

Two-speed gear drives have been proposed or used in which it is necessary to change the pinion when changing speed. This makes a very awkward arrangement and necessitates quite a lengthy shut-down when changing speed.

The drive developed by The Farrel Foundry Company, and shown in the illustration, comprises one complete self-contained unit. The two pinions are integral with the flywheel shaft. Each drives a wheel mounted on the shaft coupled to the mill. Each of these wheels is bushed and can rotate independently on the shaft. The driving connection is made by means of a gear tooth clutch, which is placed between the two wheels and is mounted on the low speed shaft. This clutch member engages with teeth cut in the hubs of the wheels. It is mounted slideably on its shaft which it drives by splines cut integral in the shaft. It is operated by a lever placed outside the

gear case. This lever is conveniently placed and the change of speed can be made instantly by simply pulling over the lever; only one wheel can be engaged with the shaft at once so there is no danger of both gears being in driving connection at the same time.

Forced lubrication is provided throughout. The pump for the lubricant is driven from the high speed shaft of the gear unit. All the bearings are supplied with oil under pressure and the gear teeth are lubricated by means of sprays from the same oiling system. Therefore, the gears do not churn oil, and in this way the maximum mechanical efficiency is obtained.

The second unit of the same design is at present being installed at the Latrobe Electric Steel Company's plant. It is believed that this type of two-speed drive can be advantageously applied to a great number of mills. It appears to have the advantages of reliability, simplicity and low first cost. It provides a large range of ratios. That is to say: Almost any standard speed motor can be used and any two convenient low speeds can be adopted to suit individual conditions.

The provision made for ample lubrication is especially noteworthy. This system provides positive lubrication to every moving part, including the bushes in the bores of the wheels. These bushes are lubricated through the low speed shaft which is made hollow. The sliding clutch is also lubricated in the same way. A thrust collar is provided on the low speed shaft to take the thrust of the wobblers. This is also forced lubricated. A larger strainer is provided in the lubricating system and this strainer can be cleaned when the drive is in operation. The drive illustrated is connected to the motor by means of a Sykes universal flexible coupling, made by the Farrel Foundry & Machine Company.

Turbine Saves \$39,660 a Year

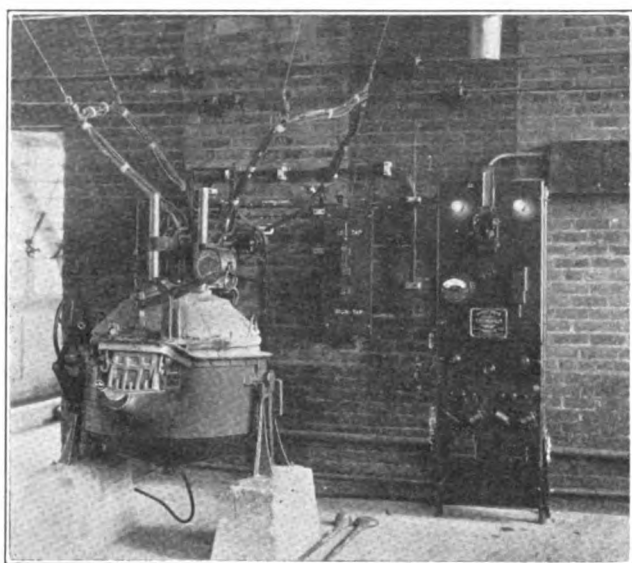
Following the installation of a mixed pressure turbine generator, the Henry Vogt Machine Company, Louisville, Ky., saved \$39,660 a year on the cost of generating power as compared with results obtained with previous engine driven equipment. Steam is generated by boilers both for the turbine and for forging hammers, the exhaust steam from the latter not having been utilized by the previous equipment. With the present installation, exhaust steam from forging hammers and air compressor is fed to the second stage of a three-stage, 750-kw., General Electric turbine.

In addition to the power generated on the premises, this company also purchases some power from the local utility and the cost of current is based on the total cost of both purchased and generated current. Under the old conditions, the cost of current averaged \$.035 per kwh. and, with the new equipment, \$.015 per kwh., resulting in a saving of \$.020 per kwh. This saving, in one year, amounted to \$39,660 and, on this basis, it is expected that the total cost of power plant and equipment, together with new a.c. motors in the factory, will be paid for in 3¼ years.

Laboratory Electric Furnaces

To meet the increased demands of technical schools, research laboratories and industrial plants for small and reliable melting-furnaces, the Pittsburgh Electric Furnace Corporation has designed and installed several types of Junior 'Lectromelts. These furnaces are giving excellent results in numerous important metallurgical investigations and have proved especially advantageous in instructing students in the increasingly important electric methods of melting and refining. These furnaces are also used by a number of companies for making small, special-analysis heats in regular production.

The success of these small furnaces is due to the fact that they are sturdy, easy to operate, and built



for practical operation. The same principles which have made their big brothers the most rapid and economic electric melting-furnaces on the market today are rigorously followed in their construction and design.

The largest of these furnaces is the 250-pound-per-hour, three-phase, direct-arc 'Lectromelt furnace. This furnace is usually operated at about 500-pound heats and can, of course, handle heats of from 700 to 800 pounds without excessive overload. Three-phase operation is advantageous from the standpoint of a balanced load and consequent satisfactory performance from the modern central station viewpoint. While this furnace will, in many cases, be somewhat larger than is usually desired for research or instruction purposes, one school sells the castings made in its foundry department, so that the furnace is self-maintaining.

This installation duplicates on a smaller scale all the improved features of 'Lectromelt design: large, tight-closing, counter-balanced furnace doors; the large forward and backward tilt of the furnace; the mounting of the electrode winches and motors in the transformer room; the tilting gear all placed above floor level; and the quadruple roller-bearing cross-heads, automatically adjusted by counterweighted electrode cables to give the desired heat input, are but a few of the details of design which assure ease and convenience of operation.

Next in size is the 125-pound-per-hour furnace shown, probably the most popular of these Junior 'Lectromelts. This furnace, while rated at 125 pounds of acid steel per hour, is usually operated at about 250-pound heats and will hold 300 pounds if necessary. The illustration below shows one of these furnaces in operation on a special-alloy heat. Among technical schools, research laboratories and industrial plants, where this size furnace is in operation, are the United States Bureau of Mines, the University of Pittsburgh, the Baldwin Locomotive Works, the Bethlehem Steel Company, the Ford Motor Company, and many others.

New Blast Furnace Blower

A new blast furnace blower, announced by the General Electric Company, was developed with three objects in view: (1) Reliable mechanical operation; (2) high overall efficiency, and (3) improved pressure-volume characteristics.

The new design includes three sizes of machines which cover the entire range of American blast furnace requirements. Each unit consists of a blower and a driving turbine, each rotating element being supported by two bearings and the two rotors connected through a flexible coupling.

The turbine is the General Electric high efficiency multi-stage type developed about three years ago for blower and generator drive. The compressor design was adopted after several years of study of the most efficient means of velocity-pressure conversion with highly efficient cooling of the air during compression. Instead of discharge vanes, previously employed for the conversion of velocity into pressure, the air passages immediately beyond the impellers are shaped in such a manner as to obtain more efficient conversion and improved pressure-volume characteristics.

The complete machine is controlled by a constant volume governor of new design, installed on the inlet of the compressor. This device automatically regulates the speed of the unit so as to produce the pressure required by the furnace at any instant. This governor, therefore, automatically maintains the delivery of air to the furnace at a constant rate, regardless of periodic changes in the resistance offered by the furnace, and also regardless of reasonable variations in steam pressure, superheat and vacuum under which the turbine is operating.

A 45,000-cu. ft. unit and a 60,000-cu. ft. unit of the new design were recently tested at the Lynn plant of the General Electric Company, and all requirements were fully met.

During the month of January The American Heat Economy Bureau, Inc., of Pittsburgh, booked the following orders for Steinbart Combustion Control on:

Eight stoves at the Ohio Works of the Carnegie Steel Company. This is the third order from the Carnegie Steel Company during the last three months, so that they have 24 stove equipments under construction for them.

Four stoves from the A. M. Byers Company, Girard, Ohio.

Four stoves and four 500-hp. boilers from the Tata Iron & Steel Company, Ltd., Jamshedpur, India.

One stove burner installation for Guest, Keen & Nettlefolds, Ltd., Cardiff, England.



Mr. E. C. Sheets, for the past 17 years connected with the Engineering Department of the Wheeling Steel Corporation, has resigned his position as field engineer with that organization and is now engaged in the industrial maintenance business with offices at 207 Fitzsimmons Bldg., Pittsburgh, Pa.

The Trinity Valley Iron & Steel Company, Fort Worth, Tex., has plans under way for extensions at its plant to be used primarily for increased capacity in the steel fabricating department. It is purposed to build two one-story additions about 45x150 ft., and 32x90 ft., to cost approximately \$60,000. A list of additional equipment to be installed will be arranged at an early date.

The Michigan Steel Corporation, Wyandotte, Mich., has completed plans for the erection of a new addition to its mills, comprising a one-story unit, 60x300 ft., to be equipped for considerable increase in capacity. It is reported to cost close to \$75,000, with machinery.

The Kalman Steel Company, North Michigan Avenue, Chicago, Ill., will proceed with the erection of a new addition to its plant for the production of steel bars, to be one-story, 50 x 70 ft., estimated to cost close to \$40,000. A contract for the building has been let.

The Standard Seamless Tube Company, Pittsburgh, Pa., has plans for the early erection of a new addition to its mills at Economy, Pa., consisting of a one-story structure, reported to cost approximately \$85,000, with machinery. It is purposed to develop a large increase in output.

Arthur F. Blasdell, general manufacturing superintendent, General Electric Company, Pittsfield, Mass., resumed his duties Monday. For the past six months he has been in southern California.

Parker F. Wilson, who recently joined the Wheeling Steel Corporation, Wheeling, W. Va., has been made assistant to President I. M. Scott. Mr. Wilson has been engaged in operating capacities for a number of years and more lately was vice-president and general manager of the Otis Steel Company, Cleveland, with which he had been associated in various capacities for a number of years.

Harry L. Brindle, formerly master mechanic of Farrell steel works and furnaces of the Carnegie Steel Company, Farrell, Pa., has been appointed assistant general superintendent of those works.

Donald N. Watkins, formerly superintendent of blooming mills at the South Side works of Jones & Laughlin Steel Corporation, Pittsburgh, has been appointed district sales manager of the Cleveland, Detroit and Indianapolis offices of General Refractories Company, at Cleveland. Prior to joining the Jones & Laughlin organization, Mr. Watkins was editor of Blast Furnace and Steel Plant.

W. J. Nugent, vice president and general manager of the Nugent Steel Castings Company, Chicago, has been elected president to succeed Charles Piez. Prentiss Coonley has been elected vice president and C. A. MacDonald, secretary, has been elected to fill a vacancy on the board of directors. Mr. Nugent has been associated with the company since 1918, when the present plant was erected. From 1918 to 1921 he served as vice president and in 1921 became general manager as well. During this period the company enjoyed a steady growth and it is announced that there will be no change in policy as a result of the recent changes in officials. The interests of Mr. Piez have been taken over by Mr. Nugent and others. The company was organized in 1916 and has made electric steel castings since its inception. A large electric annealing furnace of recuperative type was recently installed and the entire output is now annealed in this furnace.

BY-PRODUCT AND CHEMICAL NEWS

The Weirton Steel Company, Weirton, W. Va., is continuing its expansion program and in addition to new structures now under way has arranged for the erection of a new 800-ton capacity blast furnace, on which work will be placed in progress at an early date. Contract for structural steel for the unit has been awarded to the McClintic-Marshall Company, Pittsburgh; the award for the furnaces and stoves has been let to the William B. Pollock Company, Youngstown, Ohio; and refractory brick and materials for lining, etc., will be supplied by the General Refractories Company, Philadelphia, Pa. The company has work under way on a coke and by-products plant, reported to cost in excess of \$1,000,000, and has taken over a large tract of coking coal properties near Brownsville, Pa., to provide for complete fuel supply for the new plant requirements. Arrangements will be made to develop the mining properties to large capacity.

Contract for a new tippie at the Freeburn mines of the Portsmouth By-Products Coal Company, near Williamson, W. Va., has been awarded to the Link-Belt Corporation, of Philadelphia, at a bid of approximately \$50,000. Work on the concrete foundation is to begin at once, and the tippie is to be finished by the first of September.

On completion of the improvement, the company will make an opening in the Alma seam, according to Thomas De Venney, general superintendent.

The new tippie will enable the company to load 4,000 tons of coal in eight hours, as compared to 2,500 tons loaded by the old tippie in from twelve to fourteen hours. The old tippie will be razed.

Behavior of Gas in Storage Holders

The question as to whether any dissociation takes place during storage of gas for any length of time in a holder is discussed by Dr. G. Offe, writing in the "Gas Journal". One of the Cologne holders was filled with 59,000 cubic meters (about 2,083,000 cu. ft.), and left standing for five days, after which the gas, which had been specially made for the test, was passed out in the ordinary way. During the delivery, on two consecutive days, complete analyses were made every two hours, besides which CO_2 specific gravity, and calorific value tests were made every quarter of an hour, and quantities determined hourly.

Results are tabulated of the complete analyses taken when the holder contents were 48,200, 32,200, 28,300, 20,000 and 16,500 cubic meters and they show uniformity throughout. The holder then had to be taken into ordinary use again, so that the last 16,500 cubic meters could not be tested; but the author is satisfied from the results obtained that the component gases remain uniformly mixed in storage, but the gas molecules are in constant diffusion and motion.

Carnegie Institute Fellowships

C. G. Dunkle, secretary of the Pittsburgh Section of the American Chemical Society, and a former chemist with the H. J. Heinz Company in Pittsburgh, has been appointed to a research fellowship in mining and metallurgy at the Carnegie Institute of Technology, according to an announcement. This appointment fills a vacancy caused by the death of Benjamin E. Hess, of Los Angeles, Cal., and a graduate of California Institute of Technology, who was killed on December 19 in a train wreck near Altoona, Pa.

Dunkle will continue the investigations in a "study of flame propagation in natural gas and air," that were interrupted so tragically by the death of his predecessor. Under the plan of co-operation that has been in effect for the past several years, the research work will be conducted in co-operation with the Pittsburgh Station of the U. S. Bureau of Mines and an advisory board of Pittsburgh District coal operators and engineers, with H. F. Coward, principal assistant of the Safety in Mines Research Board of England, and G. W. Jones, Fuels Chemist of the U. S. Bureau of Mines, directly in charge of the study of this problem.

The new appointee is a graduate of the University of Pittsburgh in the class of 1922, and has been a member of the staff in the chemical laboratory at the Heinz plant for the past three years.

Announcement is also made of the appointment of John W. Greene, of Seattle, Wash., to a newly-created research fellowship to study "reactivity of coke." This fellowship, it is further announced, is to be financed for the coming ten months by the American Gas Association.

The appointment of Greene, who is a graduate of the University of Washington in the class of 1925, brings the total number of research fellowships in mining and metallurgy at the Carnegie Institute of Technology this year to 12. Four of the fellowships are being financed by the Carnegie Institute of Technology, two by an advisory board of metallurgists, and the other six by funds provided by associations and industrial corporations.

Elimination and Recovery of Phenols

(Continued from page 114)

with the other neutralizing agents. When neutralizing with sodium bicarbonate under these special conditions it is obvious that another molecule of sodium carbonate results and the amount of sodium carbonate recovered in this case is 36 lb. per 1,000 gal. of liquor instead of 18 lbs. noted above, in the carbonic acid neutralization.

The writer is indebted to Mr. W. H. Wright, vice-president of the Foundation Oven Corporation, designers and builders of the entire coke plant of the Hudson Valley Coke & Products Corp., of Troy, N. Y., for permission to write this article, and for his co-operation in making the phenol installation a success.

Patent applications have been filed covering the essential features of the process above described.

NEWS OF THE PLANTS

The American Steel & Wire Company, Worcester, Mass., has completed plans and will proceed with the erection of two new mills at its local South Works, comprising a billet mill and rod mill, respectively. The new units will replace present structures which have been in service for a number of years and which require complete modernization; of the five existing mills, two billet and three rod mills, only one will be retained, this being the unit known as the No. 2 rod mill. Complete new equipment will be installed, including electric motors and auxiliary electric apparatus for the replacement of steam power service as heretofore used. The new mills will have a capacity of about 600 tons per day, or approximately the rating of the existing units, which will be continued in operation until the completion of the new structures. The entire project is estimated to cost close to \$2,000,000, with machinery. Clinton S. Marshall is district manager at the works. The company will also make improvements at its Cleveland, Ohio, plant, including the construction of a new four-story steam operated electric power plant, 100x129 ft., with equipment to utilize gas fuel from company blast furnaces in this district. The station is estimated to cost in excess of \$250,000, with equipment.

The Otis Steel Company, Cleveland, Ohio, is perfecting plans for a number of extensions and improvements in its local plant, and expects to begin work on the betterment program at an early date. The present blowing engines at the blast furnaces will be replaced with modern turbo-blowers and other improvements carried out at the stacks. The power plant at the furnaces will be increased in size and additional machinery installed to double the present output. The existing power house at the Riverside works will be used in the future as a reserve unit. The company is also considering the establishment of additional sheet mills, converting the present jobbing mills for this purpose, with the installation of necessary equipment. A decision in the latter improvement will be made at an early date. To provide in part for the betterments at the plant, the company has disposed of a bond issue of \$12,000,000, the remainder of the fund to be used for general financing. E. J. Kulas is president.

The Kansas City Steel Corporation, Kansas City, Mo., recently organized under Delaware laws with a capital of \$4,500,000, is proceeding with the erection of its proposed local plant to consist of a number of units reported to cost in excess of \$1,500,000, with machinery. The new works will consist largely of the removal and rebuilding of the former plant of the Cromwell Steel Mills, Lorain, Ohio, at the Kansas City site. The different structures will include a one-story open-hearth building, 130x340 ft.; one-story blooming mill, 55x400 ft.; one-story stripper and furnace building, 60x225 ft.; one-story finishing mill, 65x275 ft.; an office building and auxiliary structures, the entire to be located on a 50-acre tract of land to allow for future expansion as necessitated. The

initial equipment installation will consist of four 100-ton open-hearth furnaces, with annual rated output of about 250,000 tons; 30-in. blooming mill and finishing mill for rolling billets and structural shapes; 12-in. finishing mill for small merchant bar production, as well as bands, small structural shapes, etc. In addition to this equipment and other available machinery at the former Cromwell mills, considerable other machinery will be installed to round out a complete plant for structural steel shape and affiliated steel production. Contract has been let for the dismantling of the Lorain plant and the removal to the new site. The reconstruction will be carried out under the direction of the H. A. Brassert Company, Chicago, Ill., consulting engineer. It is expected to have a portion of the plant completed, including one open hearth furnace, during July. C. A. Kafer, electrical engineer, superintendent at the former Cromwell mills, is connected with the new organization and will continue to act in the same capacity.

The Carnegie Steel Company, Pittsburgh, Pa., is developing plans for further early expansion at its different plants in addition to the betterment program now being carried out at the Homestead works. The company is said to be arranging for the early construction of a new unit at the Mingo, Ohio, plant to be used for the open hearth department; this project was approved a number of months ago, but has been held in abeyance since that time. The unit will require considerable new equipment and will represent a large investment. Other betterments are also contemplated at this works. Plans have also been perfected for extensions and betterments in the coke and by-products plant at the Clairton, Pa., works, to include the installation of a new battery of coke ovens, 300 in all, with by-products equipment, estimated to cost close to \$3,500,000. This expansion will be carried out early in the spring. Following the purchase of a tract of about 100 acres of land on the north side of the ship channel at Houston, Tex., the company has authorized plans for the erection of a new steel fabricating plant at this location to handle southern business. The works will consist of a group of units, reported to cost in excess of \$500,000. In addition, large warehousing facilities will be provided at the new site and plans for these structures will be arranged at an early date. It is said that the entire Houston project will be pushed to rapid completion.

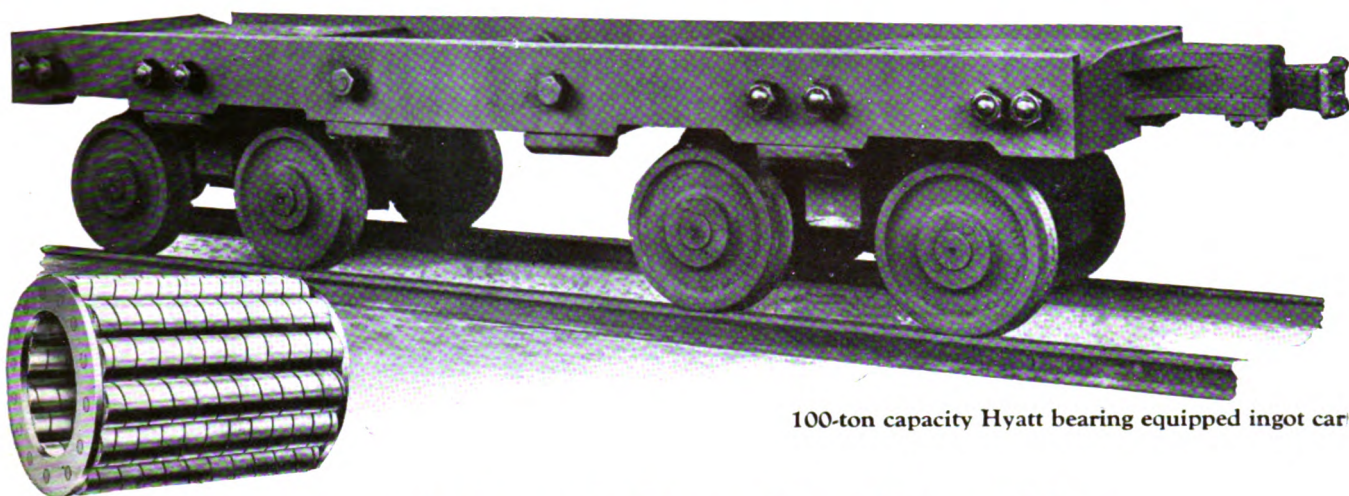
The Portsmouth Structural Steel Company, Portsmouth, Ohio, recently organized by local interests, has purchased property on Eleventh Street, Portsmouth, as a site for a new plant. Plans are now in progress for the initial unit, reported to cost about \$50,000, to be supplemented by other structures in the near future. A list of machinery to be installed will be arranged at an early date. The new company proposes to round out a modern steel fabricating works at this location. It is headed by Fred M. Ruhlman and Marthy J. Ruggles, Sr., both of Portsmouth. S. R. Wolfe will be engineer and manager at the plant.

The Blast Furnace *(and)* Steel Plant

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100-ton capacity Hyatt bearing equipped ingot car

Saving \$29.48 Per Car Per Year On Lubrication Alone

THE following comparison* of lubrication costs for plain bearing and Hyatt bearing ingot cars was compiled by one of the largest mid-western steel plants, based on records maintained over a period of several years.

For 50 ingot cars equipped with
brass journal bearings:

Monthly cost—50 cars

400 lb. grease at \$.04	\$ 16.00
26 man days at 5.00	130.00
Total—1 month	\$146.00

Yearly cost—50 cars	\$1752.00
Yearly cost—per car	\$35.40

For 50 ingot cars equipped with
Hyatt roller journal bearings:

Quarterly cost—50 cars

600 lb. grease at \$.04	\$ 24.00
10 man days at 5.00	50.00
Total—3 months	\$74.00

Yearly cost—50 cars	296.00
Yearly cost—per car	\$5.92

Saving per car per year—\$29.48

HYATT ROLLER BEARING COMPANY
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HYATT

ROLLER BEARINGS

*Since this comparison, an additional 75 cars have been changed over and are demonstrating the same economies.